THURSDAY, JANUARY 22, 1920.

WIND AND BAROMETRIC GRADIENT.

Manual of Meteorology. Part iv.: *The Relation of the Wind to the Distribution of Barometric Pressure.* By Sir Napier Shaw. Pp. xvi + 166 + 3 plates. (Cambridge: At the University Press, 1919.) Price 12*s.* 6*d.* net.

THE other parts of this manual are not yet published, but Part iv. deals with the question of the extent to which the motion of the lower strata of the atmosphere can be inferred from the ordinary working chart prepared on receipt of the telegraphic information of the surface conditions by a meteorological office, a question of great importance to the aircraft service.

As the author informs us in the preface, many inquiries of this sort were addressed to his office in London during the war, and he sets out here the extent to which and the means whereby answers to such questions can be given.

The matter is a complicated and difficult one, but Sir Napier Shaw is to be congratulated on the mass of information he has brought together and on the clear way in which he has arranged it and correlated together the different parts, which are sometimes more or less contradictory.

In chaps. i. to iii. the relation of the surface wind to the isobars is set out. The principle that the motion of the air will be at right angles to the direction of the pressure gradient and have the velocity deduced from the gradient equation is accepted as a working hypothesis, and the reasons why the rule does not hold close to the surface are explained. The principle was set out by the author thus in 1913: "In the upper layers of the atmosphere the steady, horizontal motion of the air at any level is along the horizontal section of the isobaric surface at that level, and the velocity is inversely proportional to the separation of the isobaric lines in the level of the section." How far this principle holds is a fundamental question in meteorology. Admittedly, it only applies to first order terms, and the author, in chap. x., shows that there is a systematic departure from the rule near the centre of a travelling cyclone. On the other hand, if a meteorologist is asked to give the velocity and direction of the wind at 1500 ft. height at any given time and place, it has been found, in the absence of information from pilot balloons, that the best answer he can give is to quote the gradient wind as shown by an isobaric chart.

In chaps. iv. and v. the author discusses the increase of wind with height in the lower strata, and gives G. I. Taylor's theory of the diffusion of eddy motion and its effect on the wind and on the formation of thin sheets of low cloud. Taylor's formula takes the form $W/G = \cos\alpha - \sin\alpha$, where W denotes the actual surface wind, G the geostrophic wind, and α the angle between them. It will be noticed that this formula makes a value of α exceeding 45° impossible.

Chaps. vi. and vii. deal with the variations of the wind in the upper layers and their dependence on the form of the distribution of temperature. It is shown how the cessation of the lapse rate, *i.e.* the fall of temperature with height, in the stratosphere, and the higher temperature over the cyclonic area that is found above 10 km., produce the rapid falling off of the wind that is also shown by direct observation.

Chap. x. is perhaps the most suggestive in the book, and throws fresh light on the well-worn theme of the mechanics of a travelling cyclone. It is there shown that in what is called a normal cyclone there are three centres: the instantaneous or kinematic centre; the "tornado centre," which is the centre of the supposed rolling disc; and the dynamic centre, which is the centre shown by the isobars on the chart. This representation leads to a systematic difference between the true and the gradient wind in the parts that are near the centre, a difference that has been noticed, but was supposed to be accidental, on some working charts.

In chap. xi. Sir Napier Shaw discusses Rayleigh's and Aitken's papers on revolving fluid, and gives diagrams and reproductions of instrumental records relating to some noted storms of the last twenty years or so. Synoptic charts are reproduced which show a good agreement with the method of treatment in chap. x. The diagrams Figs. 5 and 6, on p. 154, are especially striking; they refer to the storm of September 10, 1903, at Holyhead, and show the velocity and direction of the wind on that occasion corrected for the known peculiarities of the exposure due to the local configuration.

In theoretical discussions of the mechanics of a cyclone, especially if there is much mathematical analysis, one is unavoidably compelled to make hard-and-fast suppositions, and the point arises as to what extent the real cyclone will submit to be bound by such suppositions. The author questions how far the "normal cyclone" of chap. x. is the real cyclone as shown on the charts, and one wonders how far Rayleigh's conclusions are vitiated by his leaving out the effect of the rotation of the earth. Doing so greatly simplifies the equations of motion, but it is the earth's rotation which ensures that every cyclone in the northern hemisphere without exception shall rotate in one direction only, and every cyclone in the southern

hemisphere in the opposite direction. It must therefore be of supreme importance.

Every serious student of meteorology should obtain Part iv. of the manual and read it, and all will hope that the other parts may be published shortly. W. H. DINES.

RESEARCHES ON FLUORESCENCE.

Researches in Physical Optics. Part ii. *Resonance Radiation and Resonance Spectra.* By Prof. R. W. Wood. (Publication No. 8 of the Ernest Kempton Adams Fund for Physical Research.) Pp. viii + 184 + x plates. (New York: Columbia University Press, 1919.)

THIS is the second instalment of a valuable re-publication of Prof. Wood's papers. The first half of the volume deals with the spectroscopic properties of iodine vapour, particularly the study of the fluorescent spectrum with high resolving power. The difficulty with this, as with most other modern optical experimenting, is lack of light, and the success attained in overcoming the obstacle by well-thought-out optical arrangements is very remarkable; but the complexity of the phenomena brought to light is such as may well make theoretical progress seem almost hopeless.

It has been possible to obtain monochromatic stimulation at one particular absorption line of the iodine spectrum by the ingenious but simple device of using the mercury vacuum arc as illuminant. If the arc is run at low-current density, one line only of the iodine spectrum is covered by the green mercury line. Even in this case the result is to stimulate not merely the line primarily excited, but also a series of doublet lines, extending along the spectrum on either side of the latter. Stokes's law of fluorescence is thus completely violated.

All this results from the stimulation of one line only of the iodine spectrum.

But this line is one of forty thousand, and it appears that we can scarcely rely on it as being typical, since the iodine lines are of many varieties, as shown by their minute structure and by the Zeeman effect and the magnetic rotatory properties.

No doubt what is wanted for this class of research is some means of obtaining intense monochromatic stimulation of great purity, and with its frequency under control over a wide range. Prof. Wood is able to do something in this direction by altering the current through the mercury arc, and thereby the width of the green mercury line; this makes it overlap several of the iodine lines, and the complexity of the phenomena is thus greatly increased. It is perhaps worthy of consideration whether the Doppler effect obtained by moving the source could be of service, but this method would probably be very difficult of execution, and the range that could be hoped for very far short of what is desired.

The second half of the volume deals with other phenomena of fluorescence in gases of a miscellaneous kind, but is marked throughout by the same fertility of resource in devising experimental methods. The re-emission of the mercury radiation at wave-length 2536 when cold mercury vapour is stimulated by this radiation is an observation of special importance; the question presses for answer how this resonance is related by the scattering of white light by gases when there is no resonance. R.

SCIENTIFIC STUDY OF THE SUGAR GROUP.

The Simple Carbohydrates and the Glucosides. By Dr. E. Frankland Armstrong. Third edition. (Monographs on Biochemistry.) Pp. x + 239. (London: Longmans, Green, and Co., 1919.) Price 12*s.* net.

THE third edition of Dr. E. F. Armstrong's monograph is something more than a new and revised issue; it is, to all intents and purposes, a new book. Such a statement may not, on first inspection, seem to be well founded, as the general scheme adopted by the author in the earlier editions has been retained, and the subdivision of the material into chapters remains much as before. A comparative reading of the texts, however, shows that some of the changes introduced are fundamental, and a reader making his first acquaintance with the specialised chemistry of the carbohydrates through a study of the latest edition will thus acquire not only much new information, but also an entirely new perspective.

The seven years which have elapsed since the appearance of the second edition have been marked by considerable activity in sugar research, and the fact that Emil Fischer closed his career by once more directing the work of his school to this subject would almost in itself be sufficient to make a fresh edition necessary. Many novel and unexpected types of compounds have been isolated, and these are now fully described and classified under an improved nomenclature; but this alone does not explain the advances made in the present book.

Dr. Armstrong has been quick to realise that the recent recognition of the specially reactive forms of sugars which are regarded as ethylene-oxides has opened out many new fields of inquiry, and has made clear much that has hitherto been

obscure. He has therefore introduced the new structural ideas at an early stage of his narrative, and keeps them continually before the reader, adding on the way many fresh suggestions and criticisms. His treatment of this difficult subject is extremely lucid, and the result is strikingly successful.

Although the book has been considerably expanded by the inclusion of much new experimental material, little need be said regarding the details of the subject-matter, as nothing of present or potential importance has been overlooked, and the enlargement of the various chapters is well balanced. The high standard of accuracy maintained throughout the text extends to the comprehensive bibliography, which is carefully classified according to the topics discussed—a plan which saves time when a rapid search through the original literature is necessary.

Monographs suitable for both the research worker and the advanced student play a part of ever-increasing importance in our scientific education, and the present book is a model of its kind. Considering the magnitude and the wide appeal of carbohydrate chemistry, it is no easy task to compress within narrow limits an accurate account of the most important features of the sugars, and at the same time to avoid the dangers of merely cataloguing compounds or of losing all style in telegraphic brevity. Dr. Armstrong has skilfully avoided these dangers, and has succeeded in making his narrative interesting without sacrificing any essentials, and that this has been possible is ample testimony to the excellence of the scheme upon which the original edition was planned. The leanings of the author, as a practical worker in this field, to the biological aspects of sugar chemistry are well known, but Dr. Armstrong is a firm believer in the value of structural study, and he therefore establishes constitutional principles before proceeding to descriptive details.

It is, then, on the elastic framework of structural chemistry that Dr. Armstrong has arranged the complex facts of sugar chemistry, and he has done so systematically, thoroughly, and with scholarly judgment. No point of view is neglected. The organic chemist is not allowed to forget that Nature is the great sugar laboratory, and that he must work in association with the biologist. On the other hand, the biochemist is forced to think in the exact terms of structure, and the lesson is probably necessary.

For several years the reviewer has been in a position to appreciate the merits of the earlier editions by observing the use made of them by graduates commencing research work on the sugars. The monograph has answered most successfully to this practical test, and as the latest edition is a distinct advance on its predecessors, students of the sugar group will have access to a thoroughly satisfactory book—a book written with the authority of the expert and conveying the stimulus of the enthusiast.

NUTRITION AND LONGEVITY.

(1) *The Newer Knowledge of Nutrition: The Use of Food for the Preservation of Vitality and Health.* By E. V. McCollum. Pp. ix+199. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1919.) Price 6*s.* 6*d.* net.

(2) *On Longevity and Means for the Prolongation of Life: Founded on a Lecture delivered before the Royal College of Physicians on December* 3, 1903. By Sir Hermann Weber. Edited by Dr. F. Parkes Weber. With a preface by Sir Clifford Allbutt. Fifth (enlarged) edition, revised and partly re-written. Pp. xxii+292. (London: Macmillan and Co., Ltd., 1919.) Price 12*s.* net.

(1) PROF. E. V. McCOLLUM sets forth in volume form the results of, and conclusions to be drawn from, his well-known researches on food accessory bodies, the discovery of which was initiated by Dr. Gowland Hopkins. These bodies, called "vitamines" by Funk, are now realised to be of the greatest importance to growth, health, and resistance to disease, the lack of them making the body susceptible to the rank growth of microbes.

Prof. McCollum inclines to doubt that scurvy is due to the lack of a water-soluble accessory body A, strong evidence for the existence of which has been adduced by the workers at the Lister Institute, Dr. Harden, Miss Chick, and others. He lays the greatest stress on the fat-soluble A accessory body, which is of supreme importance for growth, and is to be found in growing cells and in milk, eggs, and the germ of seeds (wheatberry, etc.), substances specially formed with growth principles in them. The miller removes the germ in the preparation of white flour, and, classed as offal, it goes to feed and promote the growth of pigs and chickens.

Dairy produce from cows fed on green leaves and the green leaf itself supply "fat-soluble A," and are thus the great protective foods, and every endeavour must be made to keep up the supply of these. Green vegetables must not be regarded

as a luxury, but as a most essential part of the diet. The citizen is divorced from gardens and allotments, and the cost of transport makes a cheap supply of greenstuff prohibitive. Milk has become costly, and even when cheap was not much drunk by the children of the poorer classes. How many schools recognise the imperative needs of children for green vegetables, fruit, and abundance of milk?

The fatality of the recent epidemics of influenza may have been closely associated with deficiency of fat-soluble A in the diet, for there is none in the vegetable-oil margarine which has so largely replaced butter.

(2) The fifth edition of the late Sir Hermann Weber's book on longevity, edited by his son, Dr. Parkes Weber, is prefaced by Sir Clifford Allbutt by many wise and illuminating remarks. The motto of the author is no less old than true. "Work, moderation, and contentedness are the main sources of health, happiness, and long life." A great apostle for open-air exercise, he justly extols walking and climbing above all forms of exercise. He lived to ninety-seven himself, following the wise tenets which he lays down.

It is often asserted that longevity is an inborn quality, and the cases of men are cited who have attained old age and yet have been heavy eaters or drinkers. Inquiring into the manner of living and other antecedents of more than 100 persons living to between 86 and 102 years, Weber found that although most of these persons belonged to the well-to-do classes, and were not obliged to restrict themselves, there were not more than six amongst them who had more or less habitually indulged themselves by eating or drinking largely; many, on the contrary, were remarkable for great moderation. He records the cases of many middle-aged people with bad family histories and showing themselves signs of breaking up in health who, by his regimen of open-air exercise and great moderation in food and alcohol, were carried on in good health to eighty years or more, while their brothers and sisters, following no such regimen, died twenty years or so before them. The evidence Weber thus adduces seems strong enough to support his claim that great moderation in eating and drinking, and plenty of open-air exercise, can promote the duration of life of the middle-aged to a marked extent. The degenerations of the blood-vessels and other organs which hasten the end of life are primarily due to toxins absorbed from the bowels or from infections—*e.g.* rheumatic fever, syphilis, etc. A clean, healthy life keeps these away.

CHEESE- AND BUTTER-MAKING.

(1) *The Book of Cheese.* By Charles Thom and Prof. Walter W. Fisk. (Rural Text-book Series.) Pp. xvi + 392. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1918.) Price 8*s.* net.

(2) *Practical Butter-making: Fourth Revision. A Treatise for Butter-makers and Students.* By C. W. Walker-Tisdale and Theodore R. Robinson. Pp. 143. (London: Headley Brothers, Publishers, Ltd., n.d.) Price 5*s.* 6*d.* net.

(1) THE greater interest which is being taken in the manufacture of cheese will assure a welcome for this volume. It is one of the well-known series edited by Prof. L. H. Bailey, and it thoroughly warrants its inclusion in the list.

Practical cheese-making has not had in this country the study it requires to have, and whilst a number of the standard cheeses have originated here it cannot be said that, apart from Prof. Lloyd's investigations in the making of Cheddar cheese, any serious attempt has been made to throw light upon the details of manufacture or to explain the causes of the failures which arise from time to time.

In this volume the authors deal systematically with the general method of cheese-making, and state in simple language the process of milk coagulation and the theories which have been advanced in explanation. A chapter is devoted to "starters," and it would be well if our dairy students could receive greater facilities for preparing and judging the cultures and noticing the effect upon the cheese of a bad starter. A clean acid starter has a great influence upon the texture and flavour of the cheese, as is well known, and a maker who works with a bad starter cannot hope to produce a first-class cheese. Inability to judge a good starter may mean the continuance of flavours and faults which would have disappeared had the proper type of starter been used.

Amongst the hard cheeses, chief place is naturally given to Cheddar, as this type is the one commonly made in America and Canada. The appliances suitable for a factory making Cheddar cheese are described, and the process of making the cheese is followed step by step. Various types of cheese made in different countries, but all prepared upon the Cheddar principle with greater or less modification, are reviewed.

The "Book of Cheese" has many other interesting chapters, one even upon the food value of cheese, the method of using it, and recipes for dishes in which cheese plays an important part.

Milk-testing by the Babcock method is described, and numerous other tests, such as Hart's test for casein, and the testing of cheese for fat by a modified Babcock method, are given. The accuracy of the latter test is questionable.

(2) Butter-making is somewhat under a cloud at the present time, owing to the impossibility of producing it commercially at a profitable price. The information given by the authors is, however, excellent, and the best up-to-date methods and appliances are described.

The extension of the practice of selling milk, and the facilities now afforded the farmer by the wholesale dealer or the condensing factory, have not encouraged the breeding of cows giving a high percentage of fat in the milk, and it is difficult to see how butter-making can for some time to come compete with cheese-making or milk-selling. Nevertheless, there will always be a good demand for high-class butter, and it is most necessary that the maker should produce an article of prime quality. This volume would not have reached a fourth revision unless it had met with success in previous editions, and both as a manual and a reference book it takes a very high place.

OUR BOOKSHELF.

Enjoying Life: and Other Literary Remains of W. N. P. Barbellion [*B. F. Cummings*]. Pp. xvi+246. (London: Chatto and Windus, 1919.) Price 6*s*. net.

THIS book is welcome because it raises a much pleasanter picture of its author than did the rather peevish "Journal" reviewed in these columns in July last. Some of the essays, excluded from the "Journal" for reasons of space, would have illuminated its shadows. One is called "Crying for the Moon," but Barbellion wanted to swallow the Universe. Even those of us who would be content with the World have to learn that it is too large an oyster. Life is a perpetual renunciation of the unattainable. Barbellion had yet to realise that the half is greater than the whole; his only limitations were those of a sickly body, and so he seemed to scorn those who restrained the appetite of the soul. Hence, in the diarist, an apparent poverty of human kindness. But in his outward relations, as Cummings, the defect is made good or hidden. There is sympathy as well as skill in his sketches of Spallanzani, Montagu, Rousseau, and Goldsmith of the "Animated Nature," and even for his colleagues, the Scarabees, he has a good word, for he has begun to realise that the driest museum entomologist may have beneath his dusty coat something of a Barbellion.

It is ungracious to criticise lapses in a posthumous publication, but "Sir Hercules Reed," "Museo di Stovia Naturale," and "Sir Francis Galten" might have been avoided.

The Manufacture of Chemicals by Electrolysis. By Arthur J. Hale. (A Treatise of Electrochemistry.) Pp. xi+80. (London: Constable and Co., Ltd., 1919.) Price 6*s*. net.

IN this monograph a brief account is given of the application of electrolysis to the preparation of chemical products. Most of the electrolytic preparations of which a description has been published are referred to, and references to the original publications are given throughout, so that the book is likely to prove a useful guide to the literature of the subject. The reader is, however, left to guess that certain groups of preparations, such as chlorine, sodium, and the alkalis, to which no reference at all is made either in the text or in the preface, are to be described in other monographs of the series. This probably accounts for the impression created on reading the text that the academic aspects of the subject have secured in this volume undue prominence as compared with its industrial applications. If, however, all the really productive processes have been reserved for other writers, and the author of the present volume has been left to cultivate only the more barren areas, he cannot be blamed for the unfruitfulness of so large a proportion of the preparations which he describes, and is rather to be congratulated on having given so good an account of the minor applications of electrolysis to chemical industry.

A Synoptical List of the Accipitres. (*Diurnal Birds of Prey.*) Parts i. and ii. By H. Kirke Swann. (London: John Wheldon and Co., 1919.) Price 4*s*. per part.

THE literature of an attractive Order of birds receives a notable addition in this work. It is now nearly half a century since the late Dr. Bowdler Sharpe's "Catalogue of the Accipitres," the latest complete work on the subject, appeared. During this long interval innumerable contributions have been made to the knowledge of the Order relating to the discovery of new species, the recognition of numerous racial forms, changes in nomenclature and classification, extension of geographical range, and much else. Thus a treatise, however modest, which might bring the subject down to date was a desideratum, and now, in a measure, has been supplied in a highly epitomised form by this synoptical list, which furnishes concise diagnostic characters of families, genera, species, and subspecies, and also an indication of the geographical range of each bird. For the species, however, it has been found impossible to deal with any but the plumage of adults, for the varied feather changes through which many species pass ere they assume the garb of maturity could only be satisfactorily described in an elaborate monograph on the Order; as yet there does not appear to be any signs of the advent of such a much needed work. Great care has been bestowed upon the preparation of this list—a task of no small difficulty—and it will be much appreciated by all who are engaged in systematic ornithological studies.

LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.]*

Gravitation and Light.

IN a recent letter (NATURE, December 25, p. 412) and elsewhere I have expressed doubt as to the security of the inferences regarding the influence of gravitation on the light from distant celestial bodies, which are advanced as tests of the Einstein formulation. A closer and less sceptical general scrutiny is possible. The difficulty was to recognise how a theory which professes to supersede an æther with its definite space and time, by concepts purely relativist, could manage to effect direct comparison, at a distance and without tracing transmission across the intervening space, of the radiations of a molecule at the sun and those of a molecule of the same substance at the earth. This body of doctrine seems, in fact, to consist of two chapters. A blind man could work out the purely relativist theory, which would indeed represent rather closely the process of groping from point to adjacent point in space and time by which he must acquire his own scheme of knowledge. But to compare his results with the world of experience a practical astronomer is needed, with very different equipment; he relies on the rays of light, in conformity with the optical theory that prescribes their function as messengers across space.

It thus appears to be necessary to examine directly what changes in the propagation of rays of light would arise under the modified gravitation, and, if possible, to bring out more explicitly and demonstratively the further postulate that is needed to reconcile them with the proposed test-relations. The postulate which is sufficient to sustain the optical predictions proves to be this: that all the way to the sun and throughout the solar system the formula for the element of fourfold length by which the nature of the space is determined does not contain explicitly that one co-ordinate which is more especially related to time, but involves only its differential. This is, of course, a reasonable assumption; but it is of an absolute type regulating the whole space, assumed to be thus settled in advance on the Newtonian plan, not of the relativist type which would profess only to explore it gradually from place to place as it arises.

But we can analyse further and more definitely. The new theory implies that if this quadratic formula characteristic of the space involved in its product terms the differential of that co-ordinate which stands closest to time, then the velocity of the rays of light in any direction at any place would be different according as they are travelling forward or backward. That could only mean that the co-ordinates define at such a locality a frame of reference which is itself in motion. But in motion with reference to what? The relativity of language is doubtless capable of supplying an answering formula; but it would only be wrapping up in abstractions the simple statement that when at any place the quadratic characteristic of the spacial extension involves the differential of the co-ordinate specially related to time in its product terms, then there is latent in it a specification of its own mode of change at that place with respect to uniform space-time. If no such products are contained, the space is not locally in motion, and we may say that the frame of reference is fixed in the æther. That is, the fourfold space-time frame in which we set the universe is everywhere deformed and awry, but it is then nowhere in movement relative to light; or, in graphic terms, the co-ordinate system would involve a fourfold curvilinear frame instead of a rectangular one when it is set in a uniform fivefold extension, but it is to be nowhere in movement when set in that higher auxiliary space. The physical properties of the rays of light can scarcely be invoked to obtain an astronomical test of results, by providing in their vibrations a universal scale of time, without becoming to the same degree a criterion of the relation to light of the whole construction; if they can settle universal time by optical vibrations, they can equally well be applied to settle absolute space in each locality. It comes to this, that radiation can be utilised to determine the space and time absolutely.

This point of view involves no destructive criticism of the substantial and brilliant mathematical theory, which, of course, ought to evolve correctly the consequences of the postulates that are put into it. But it does demur to the popular presentation which asserts that space and time and the æther have now been transcended. The outstanding problem, stripped to its essentials, was to find whether gravitation could be brought into line with radiation in this very arresting feature: that the time which is most appropriate by far for its analytical formulation is a changing local time mixed up definitely, though very slightly, with spacial relations. The value of the new theory is that it opened out a way by which this problem could be attacked, while previously no approach was in sight; and, still more important, that it has not improbably led to an answer in the affirmative. This, of course, is a very remarkable consummation, comparable to Faraday's detection of an influence of magnetism on light, though more fundamental in that it relates to free space; it must promise substantial advance as regards the formulations on which we construct our ultimate plan of physical activity, either along its present lines or some other that would represent the result with equal approximation. But beyond that the extreme relativist developments, where they are not metaphysical dogmatics, are a very interesting extrapolation towards the possible or probable physical formulation of a universe in which bodies are moving thousands of times as fast as the stars are found to move in our own.

Reference may be made to forthcoming Proceedings of the Cambridge Philosophical Society and Monthly Notices of the Royal Astronomical Society.

Cambridge, January 17. JOSEPH LARMOR.

The Outlook of British Technical Optics.

THE symposium and general discussion on "The Microscope: Its Design, Construction, and Applications," held in the rooms of the Royal Society at Burlington House on January 14, under the auspices of the Faraday, Royal Microscopical, Optical, and Photomicrographic Societies, in co-operation with the Optical Committee of the British Science Guild, with Sir Robert Hadfield, president of the Faraday Society, in the chair, was a landmark in the history of British optics. Whether judged by the number, value, and variety of the exhibits and the papers contributed, or by the number of people who attended, the symposium was a success.

At the present time the microscope possesses a unique interest for those concerned with British optical industries. It demands greater technical knowledge and skill in its designer and producer than any other optical instrument, and the demand for it, both actually and potentially, for work of the most far-reaching importance is so great that it may fairly be said to be the keystone in the arch of an industry which has already been recognised as one of such

vital national importance as to constrain the Government to treat it as a "key industry." But there is no royal road to success even in manufacture and commerce. If this country is ever to stand in the forefront as a producer of microscopes for the world's needs the position to-day must be boldly and courageously faced. The lessons of the war must not be forgotten. We shiver yet when we remember the single thread upon which the production of optical munitions depended in this country. Our glass-makers, beaten by their foreign rivals, receiving neither help, encouragement, nor even recognition from the Government, had been content to continue their patriotic efforts to maintain the industry, on the urgent representations of a few far-seeing scientific men, until long after those efforts held out any promise of pecuniary reward. That danger, happily, has passed, and the complete solution of the optical glass problem is now only a question of time. Many of the glasses now produced in this country compare favourably with the best of those of our foreign rivals. The varieties available are limited, but the leeway is being rapidly made up.

It is often stated that the late supremacy of the Germans in optical production was the direct and necessary result of the glass-making labours of Abbe and Schott completed in the year 1886. This is not a correct statement of the case. The fact is that, when Abbe and Schott broke down the barriers to optical progress imposed by the limited varieties of glass available, Germany had in reserve a small army of scientific workers, equipped with the necessary technical knowledge and skill, ready to fill the breach and carry on the work of utilising the new glasses in the invention of new optical systems and in the improvement of old. But the world moves quickly, and inventions and discoveries, however valuable intrinsically, are likely to remain barren unless a country has a sufficient number of men equipped with the necessary knowledge to exploit them instantly and to the full. Indeed, it is only such men that can appreciate the value of inventions and discoveries. The necessity for a broad and generous scheme of national education in optical matters thus becomes apparent. When the users of optical instruments are sufficiently educated to be able to distinguish and appraise good designs and work, makers will be encouraged to meet their demands. In the absence of such education the faddist has his day, and the maker concerns himself too often in meeting the demands of fashion.

It is satisfactory to know, then, that, so far as this country is concerned, a great deal has already been done to foster optical education. The establishment of the Technical Optics Committee, which includes representatives of the British Optical Instrument Makers' Association, the War Office, the Admiralty, the National Physical Laboratory, the London County Council, the Royal Society, and the Imperial College of Science, is in itself sufficient evidence that the question has been taken up with great thoroughness. The establishment of a department of optical engineering and applied optics at the Imperial College will ensure a supply of capable and well-educated young men for the needs of the industry generally. Prof. Conrady is doing yeoman service in the establishment of an English school of optical designers and computers, the need for which was so acutely felt during the war. The outlook, then, so far as education is concerned, is decidedly promising. Indeed, in some important respects the scheme of education here is already in advance of that of any other country.

When we turn, however, to the purely engineering side—the production of the microscope as a mechanical instrument—the outlook is not so satisfactory. At the present time the Government is pledged to afford protection to the optical industries. This will probably be done by a continuation of the licensing system, which has for the moment been suspended because of Mr. Justice Sankey's decision, but there is little doubt that the system will be reimposed, either by the reversal of that decision or by legislative enactment. Now the public at the present time, with just cause, are very suspicious of anything in the nature of Protection. During the past few years Protection has so often resulted in unscrupulous profiteering at the expense of the community that the public may well be excused for looking with suspicion upon any proposal to continue the system. In the case of the microscope, for example, there is little doubt that at the back of the minds of many people there is a fear that Protection will be taken advantage of by manufacturers to foist upon the market inferior goods at greater prices than could be obtained in a free market. But the symposium has proved conclusively that this danger, in the case of microscopes at any rate, is a very small one. One or two important makers exhibited new models, designed for mass production, which showed clearly how thoroughly and seriously the problem had been taken up. Microscope production in this country is now a young, vigorous, and promising organism, which, in the course of a year or two, will probably be able to stand up and fight its way in the world without artificial support.

The real difficulty at the present moment lies in the fact that efficient production means mass production, and mass production means large enterprises carried on with large capital. Everyone is agreed that production by the old methods, requiring the employment of a large proportion of highly skilled craftsmen—the artistic method—must be replaced by machine methods. Efficient and successful production in the case of the microscope involves, as it does in so many other cases, specialisation, standardisation, and the use of repetition machinery attended by unskilled labour to produce interchangeable parts, the whole of the activities being supervised and directed by the highest technical knowledge and skill. But this involves the speculative investment of capital. The maker, on the other hand, who can ensure a moderate success with little risk by carrying on producing operations on a small scale to meet the immediate needs of the country is under a great temptation to do so rather than risk everything in an attempt to secure large profits by mass production. The present position, therefore, is a serious one for the trade generally. If the mass production of optical instruments is necessary to the success of the industry and to the realisation of the end and aims of the Government, then it is very unlikely that that success will be achieved by Protection alone. Some much more substantial assistance must be given, and this assistance is not likely to be given by private enterprise.

An interesting fact brought out by the papers and discussions at the symposium was the urgent demand for greater resolving power in the microscope. This matter was particularly dealt with by Mr. J. E. Barnard, who showed a very interesting series of slides taken with the ultra-violet microscope to demonstrate the greater resolution obtainable with the shorter wave-length light. The metallographers, on the other hand, in some cases appeared to be insisting upon large magnifications without always clearly recognising that these do not involve greater resolution. The half wave-length limit to resolution, first advanced in effect by Fraunhofer, cannot substantially, at any rate, be evaded, and this fact must be clearly recognised.

F. CHESHIRE.

Imperial College, South Kensington.

Power from the Sun.

WITH reference to Mr. A. S. E. Ackermann's letter in NATURE of January 15, in which he states that, in putting the possible efficiency of obtaining power from the sun with the heat engine at less than 2 per cent., I have used too low a figure, I may point out that, whereas Mr. Ackermann's figure of 4·32 per cent. was a maximum obtained presumably under specially favourable conditions, and as I understand in Egypt, in suggesting a figure of less than 2 per cent. I was referring to what could be expected "in this latitude and in this climate"—that is to say, in England, and also as an average during the hours of daylight throughout the whole year.

For the purpose of my argument, and in comparison with the very much higher efficiencies that are theoretically possible if the radiation can be directly utilised without first turning it to heat, with the consequent avoidance of the second law of thermodynamics, I do not think that the difference between 2 and 4 per cent. is of much importance; but, even so, I should be surprised to learn that Mr. Ackermann would expect to obtain an efficiency of even 2 per cent. anywhere in England throughout the year.

A. A. CAMPBELL SWINTON.

66 Victoria Street, S.W.1, January 17.

Sedimentation of Blood Corpuscles.

I HAVE noticed lately that if oxalated or defibrinated blood is put to stand in narrow tubes, the corpuscles sediment a good deal faster if the tube is inclined than when it is vertical. Thus with tubes about 2·7 mm. internal diameter there were, after 20 hours, 4, 23, 35, and 42 per cent. of clear serum with tubes inclined at 0°, 22½°, 45°, and 67½° respectively. In another rough experiment with tubes of different diameters, all filled to a height of 40 mm. with diluted blood, after 5 hours there were the following proportions of clear serum:—

mm. diam.	Vertical Per cent.	11¼° Per cent.	22½° Per cent.	33¾° Per cent.
2·7	6	20	29	51
8	5	10	15	21
14	4	5	9	12

The phenomenon seems to depend on the *vertical* height of the columns of blood, and it occurs to me that the slight Brownian movement of the lower corpuscles may interfere with the sedimentation of those above. But I should be glad if someone would tell me the explanation: the phenomenon is perhaps well known in some other form. A. E. BOYCOTT.

Medical School, University College Hospital, W.C.

The Einstein Theory and Spectral Displacement.

ONE of the "crucial phenomena" in connection with the Einstein theory is the displacement of the spectral lines towards the red when the emitting atom is in a position where the gravitational potential is large.

In the case of the sun this displacement is so small that its existence is a matter of doubt. But the amount of the displacement varies as the mass of the sun or star concerned, divided by its radius, and in the case of giant stars, such as Canopus, Arcturus, or Antares, should give a result corresponding to a recession of many hundreds, if not thousands, of kilometres per second, whereas, in fact, these stars show no abnormal radial velocities.

It may be pointed out that the effect varies as the product of the area and density, factors as to which the magnitude and spectrum of a star enable astronomers to make a fair approximation, at any rate as to minimum values.

These facts must, of course, have been considered by the supporters of the theory, and I think that an explanation would be interesting and useful.

H. FLETCHER MOULTON.

11 King's Bench Walk, Temple, E.C.

MR. FLETCHER MOULTON is quite correct in stating that the shift of the spectral lines varies as mass/radius, but his expectation of spectral shifts measured by hundreds or thousands of kilometres per second does not appear to be justified. All the evidence available, deduced from visual binaries, Algol variables, and spectroscopic binaries, points to the conclusion that the masses of the stars vary between much narrower limits than their brightness. We have no clear evidence of any star having a mass so great as forty times that of the sun; moreover, the most massive stars known to us are apparently in a much more diffused state than the sun, so that the ratio of spectral shifts is much less than that of masses.

We cannot use individual stars to test the Einstein effect, for we do not know the radial motion independently of the spectroscope, as we do in the case of the sun. All that we can do is to take the mean of a large number of spectra and see whether there is a systematic shift towards the red; such a shift does exist, and the difficulty is rather that it is too large than too small to ascribe wholly to the Einstein effect. Thus Campbell ("Stellar Motions," p. 199) says: "Of Type II. stars (that is, F5 to M), 371 have positive velocities and 352 negative. Of Type I. stars (that is, O to F4), 215 have positive velocities and 122 negative." Subdividing further, he gives the following mean velocities of recession in km. per second: B to B9, 4·93; A, 0·18; A2 to F8, 0·60; G to M, 0·91. Dr. de Sitter, taking the average mass and density of a B star as 10 and 1/10 respectively, finds 1·4 for the Einstein effect, about one-third of the observed quantity.

We do not know the character of the atmospheric circulation in the stars; this, as well as pressure effects, may well have some influence on the mean results. Taking the stars as a whole, it must be admitted that their verdict, though by no means conclusive, is, so far as it goes, in favour of Einstein.

ANDREW C. D. CROMMELIN.

Use of a Prismatic Binocular for Viewing Near Objects.

A FEW years ago, with a view to the observation of close objects out of doors, I procured some glass adapter lenses for use on the object glass of the half of a prism binocular (×12) which I carried about with me. Finding, however, that this method involved the use of several glass adapters, and that with it I had to know the exact distance of my objective, I prevailed on an optician—after lengthy argument, he deeming the experiment impracticable—to remove the eyepiece and refit it for use with a long screw thread. The result was most satisfactory; by this device I can draw out the eyepiece and adjust it to the proper distance for any observation down to four feet off. This device is also very useful for indoor work, such as observation on the occupants of an aquarium.

The device may be useful to other observers, who will find that the necessary alteration can be easily made.

D. WILSON BARKER.

Flimwell.

THE NITROGEN PROBLEM.[1]

I.

THE Nitrogen Products Committee was appointed in June, 1916, as a Committee of the Advisory Panel of the Munitions Inventions Department with the following terms of reference:—

To consider the relative advantages for this country and for the Empire of the various methods for the fixation of atmospheric nitrogen, from the point of view of both war and peace purposes; to ascertain their relative costs, and to advise on proposals relevant thereto.

To examine into the supply of the raw materials required and into the utilisation of the by-products obtained. Since some of the processes depend on the provision of supplies of cheap power, to ascertain how this can best be obtained.

To consider what steps can be taken to conserve and increase the national resources in nitrogen-bearing compounds, and to limit their wastage.

To carry out the experimental work necessary to arrive at definite conclusions as to the practicability and efficiency of such processes as may appear to the Committee to be of value, and to advise as to starting operations on an industrial scale.

It will be seen that the terms of reference are pretty wide, and the Committee, as is stated, have, moreover, interpreted them "in a liberal manner." The inquiry accordingly has resulted practically into a detailed examination of the nitrogen problem in its relation to the military, agricultural, and industrial requirements of the United Kingdom and other parts of the British Empire. The Committee submitted an interim report in February, 1917. As the conclusions and recommendations of that report are closely connected with the final conclusions and recommendations of the Committee, they are incorporated in the present report. The final report, with its appendices, charts, and diagrams, is a somewhat formidable document of upwards of 350 pages, the report itself occupying no fewer than 137 pages. It has been somewhat loosely constructed, and there is a certain amount of recapitulation, which was, perhaps, inevitable when regard is had to the many points of view the subject presents. But of its great value there can be no doubt. Considering the difficulty and complexity of the inquiry, it cannot be said to have been unduly protracted, and, as the result of the 106 sittings of the Committee and its Sub-Committees, we have now presented to us the most complete and comprehensive statement of the problem, as it affects this country, which has yet appeared.

The report will doubtless receive the most serious study, for it deals with matters of the gravest importance—the world's production of food, our industrial supremacy, and our national security. Indeed, its appeal is so wide, and the whole question affects so many interests, that there is a fear that no immediate action will come of it, on the principle that what is everybody's business is nobody's business. It is pre-eminently a national question, and demands the consideration of statesmen. But in the present condition of the political and industrial atmosphere we cannot hope that it will receive this. The State will wait upon private enterprise, and private enterprise will wait upon the State, each trusting, like Mr. Micawber, that "something may turn up" to avert the main conclusions to which the report inevitably points. But in view of the menace which will come from a resuscitated Germany, it would be nothing less than criminal folly to neglect the warning which the evidence now summarised conveys. Our chemical manufacturers and our producers of fertilisers must be brought to realise that synthetic nitrogen products have come to say. The days of the Chile nitrate industry are apparently numbered. If we accept the estimates of the Committee, retort nitric acid cannot, even in this country, be produced so cheaply as the synthetic product, and synthetic fertilisers are serious competitors with the natural nitrate and by-product sulphate of ammonia.

It would be impossible in the space at disposal to deal in detail with the many points and issues raised by the Committee's inquiry, and set out at length in the report. We must content ourselves, therefore, with a summary statement of the principal conclusions at which it has arrived.

With respect to the world's demand and production of nitrogen compounds before the war, it is shown that the world's consumption in 1913 was almost double what it was in 1903. The demand up to this time was practically wholly met by Chile nitrate and by-product ammonia, the nitrogen fixation processes contributing only a small, but still growing, proportion, notwithstanding their notable development during the years 1903–13. Up to 1914 the market price of combined nitrogen was governed by that of Chile nitrate, and was characterised by a general upward tendency, showing that the supply was not in excess of the demand. At the same time, synthetic nitrogen products could be placed upon the market at prices which competed favourably with ammonia nitrogen and nitrate nitrogen. That these fixation industries were in a healthy condition was shown by the fact that they had expanded more than 150 per cent. during the period 1903–13, or more than double the expansion during the same interval of the Chile nitrate industry.

The war has profoundly modified the relative position of the natural and synthetic nitrogen industries. Before the end of 1914 the productive capacity of the nitrogen fixation installations represented 10 per cent. of the world's supply of combined nitrogen; at the present time it is about 28 per cent. The post-war production of ammonium sulphate, both synthetic and by-product,

[1] "Ministry of Munitions of War. Munitions Inventions Department. Nitrogen Products Committee. Final Report." Pp. vi+357. (London: H.M. Stationery Office, 1919). Cmd. 482. Price 4s. net.

is calculated to amount to 39 per cent. of the world's supplies of combined nitrogen, Chile nitrate accounting for about 41 per cent. War developments are now challenging the supremacy of the Chilean industry. The market price of the synthetic products, and of ammonium sulphate, bids fair to govern that of Chile nitrate instead of following it as hitherto. The Committee estimates that the post-war supply of fixed nitrogen potentially available is likely to show an increase of from 30 to 40 per cent. upon the pre-war production, or to be of the order of a million metric tons per annum. It is, however, of opinion that this amount is not greater than would have been the case under normal conditions, to judge from the pre-war rate of growth in consumption. But it is significant that this increase is almost wholly due to the development of synthetic processes. There would seem to be no fear that over-production will be a serious factor in the post-war situation.

As regards the uses of nitrogen products prior to the war, at least 70 per cent. of the world's total supplies of nitrate and ammonia nitrogen was utilised in agriculture. Owing to their comparatively limited employment in this country, and the somewhat conflicting experience of our experiment stations, which, as the evidence presented to the Committee shows, have scarcely given sufficient study to the question, there is no absolute proof, as yet, that synthetic fertilisers are wholly suited to the particular circumstances of this country. The Committee, however, has no doubt as to their utility, and specifically makes mention of the value of nitrate of lime, as now manufactured, and of calcium cyanamide when free from dicyanodiamide, in which opinion it would seem to be supported by the Board of Agriculture.

Dr. E. J. Russell, of the Rothamsted Experimental Station, in a recent paper published in the Journal of the Society of Chemical Industry, states that the results of all published field trials show that the three fertilisers—nitrate of soda, sulphate of ammonia, and cyanamide—when compared on the basis of equal nitrogen content have the following values:—

Nitric nitrogen	...	...	100
Ammoniacal nitrogen	...	...	97
Cyanamide nitrogen	...	...	90

But, he adds, these include cases where the cyanamide nitrogen could have had no proper chance of acting. Cyanamide, he points out, presents the characteristic that it is not at once available for plants, but has to undergo change in the soil whereby ammonia is formed, which afterwards nitrifies. The whole value of the material, therefore, depends on the rate at which the change proceeds. In some soils it goes on rapidly, and here cyanamide is very effective. In others, however, it proceeds more slowly. The production of the ammonia would appear to take place in two stages, the first being purely chemical, and the second bacterial; further, the agent producing the chemical change is not always present in sufficient quantity in the soil. Under better advice, such as is now obtainable, the farmer could be warned beforehand, and the use of cyanamide kept to those numerous cases where it can decompose rapidly and act well. In these circumstances the value of cyanamide nitrogen might rise well above 90, and, what is more important, the risk of failure might be considerably reduced.

Of course, the war made imperative calls upon the nitrogen industries, and these, notwithstanding their expansion, were quite unable to cope with the demands for both explosives and fertilisers. The needs of agriculture were consequently largely set aside, to the great detriment of the world's food supply. The effect has been the almost universal recognition of the vital importance of nitrogenous fertilisers. The difficulties of obtaining them and the consequences which have followed from the shortage have together furnished an object-lesson which the world will not soon forget. The Committee learns that the visible demand for nitrogenous fertilisers is everywhere considerably in excess of the pre-war consumption.

With respect to the relative costs of synthetic and non-synthetic processes, the Committee concludes that under favourable conditions in regard to the cost of power and of raw materials, the nitrogen fixation and allied processes, speaking broadly, stand at a very considerable advantage as compared with non-synthetic methods. It ought to be stated, however, that all its estimates are based upon pre-war prices and factory costs, and it by no means follows that the price of coal and of water-power will advance *pari passu*. A waterfall does not "down tools" like a miner, nor does it attend football matches and go on strike for any or no cause in particular. But still, fallible as the basis may possibly be under present or prospective conditions, the comparison of costs is instructive and significant. The average market price of a metric ton of combined nitrogen in the United Kingdom during 1911–13 was 67*l.* and 66*l.* in the forms of Chile nitrate and ammonium sulphate respectively. The synthetic processes can produce a metric ton of available combined nitrogen at a cost, at the factory, of from 20*l.* to 30*l.* These processes can produce a metric ton of concentrated nitric acid (93 to 96 per cent.) at about half the cost of retort (Chile nitrate) nitric acid. Nitric acid can be produced by the oxidation process from by-product ammonia, even at its highest pre-war price, cheaper than by the old process.

It may, however, be doubted whether any of the synthetic processes, with the possible exception of the arc process in very favourable circumstances, can produce a nitrate fertiliser that would compete with Chile nitrate under conditions that the Chilean industry might be willing to adopt. Whilst improvements in the method of absorbing and recovering the oxides of nitrogen in the arc process are certain to occur, it must not be forgotten that the capital expenditure needed in in-

stalling this process is high, and bears a large proportion to the market value of the annual production.

It follows, therefore, from these conclusions that the industrial demand for nitric acid in the future will probably be met by means of synthetic processes. It is conceivable that the marketing of large quantities of synthetic sulphate of ammonia and cyanamide, made in Germany, will influence the future price of combined nitrogen, and may even control it. The Committee thinks that the producers of combined nitrogen may eventually have to face a competitive price of 7*l.* or 8*l.* per metric ton for ammonium sulphate, and 6*l.* or 7*l.* per metric ton for cyanamide. The by-product ammonia industry in this country may thus be seriously menaced. It can scarcely recoup itself by raising the price of the other by-products to any serious extent, and considering the relation of combined nitrogen to the food of the country, public opinion, whilst willing to tolerate, up to a certain extent, the protection of "key" industries, would strongly resent any action which seriously interfered with the productive capacity of the land.

(*To be continued.*)

THE MICROSCOPY OF METALS.

AT the very successful symposium on the microscope organised by the Faraday Society on January 14 in the rooms of the Royal Society, about one-half of the papers presented dealt with the microscopical examination of metals, a striking indication of the importance which this branch of microscopy has now acquired. It was therefore appropriate that the president, himself a distinguished worker in this field, should deal historically with the development of micro-metallography, as well as contributing an original paper to the discussion. Sir Robert Hadfield's introductory address surveyed the history of microscopical invention, and was illustrated by portraits of some of the pioneers in the art—Jansen, Lipperhey, Leeuwenhoek, Sorby, and Dallinger. We were reminded of the fact that, so far back as 1665, Robert Hooke described in his "Micrographia" the appearance of the point of a needle and the edge of a razor, and his faithful drawings of these two objects, revealing most accurately the features which could be observed under a low magnification, are reproduced in the paper. The next instance of the application of the microscope to the examination of metals is that by Réaumur, whose work on steel, published in 1722, contains many drawings of the magnified fractures of iron and steel bars. Such a method, however, gave little information, and did not lead to any further development. In 1808 Widmanstätten studied the structure of meteoric irons by polishing a plane section and heating until the constituents became differentially coloured by oxidation, thus introducing the method now familiar as "heat-tinting." The structure of these irons is so coarse that magnification is unnecessary, but the method gave hints to later workers, of whom Sorby is the chief. The work of Sorby, in view of its great importance, was dealt with by the president in a separate note.

Henry Clifton Sorby, one of those amateur scientific investigators who have contributed so wonderfully to the progress of science in this country, was led to devise the modern method of microscopic petrography by seeing sections of bone, teeth, etc., rendered transparent by affixing one surface to glass and then grinding down to an extreme thinness, as practised by the botanist Williamson. Sorby treated rocks in the same way, and in 1849 he prepared the first rock slice

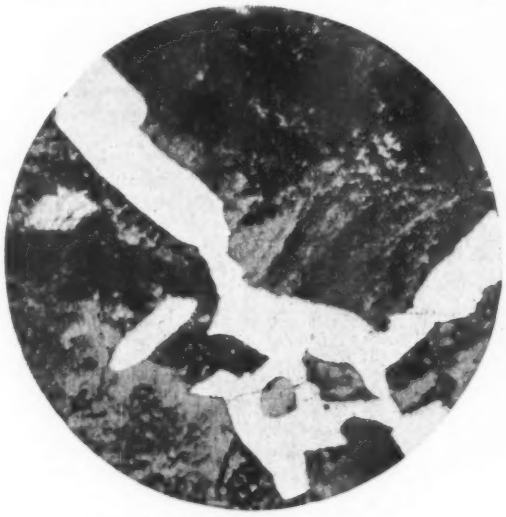

FIG. 1.—Magnification 600. 12 mm. Achromat.

FIG. 2.—Magnification 600. 2 mm. Apochromat.

Phot micrographs showing the effect of magnification without resolution The steel used in this experiment had the following composition: C 0·48, Si 0·17, S 0·029, P 0·034, Mn 1·00 per cent.

ever made. By 1851 he had become expert in the new process, and was able to publish his observations of the microscopic structure of limestones. In 1857 he presented to the Geological Society his famous paper on the fluid inclusions in quartz crystals, in which he ventured to draw

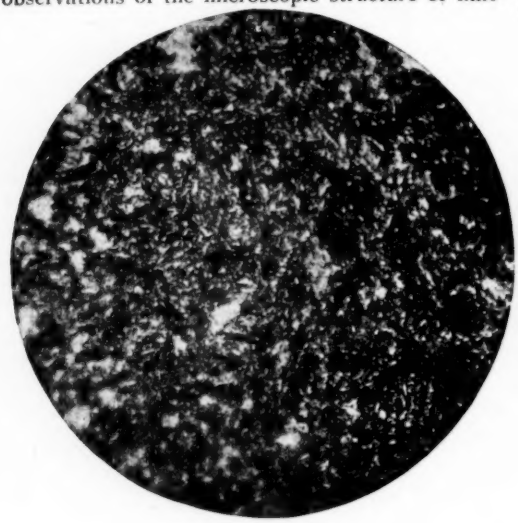

FIG. 3.—Magnification 100.

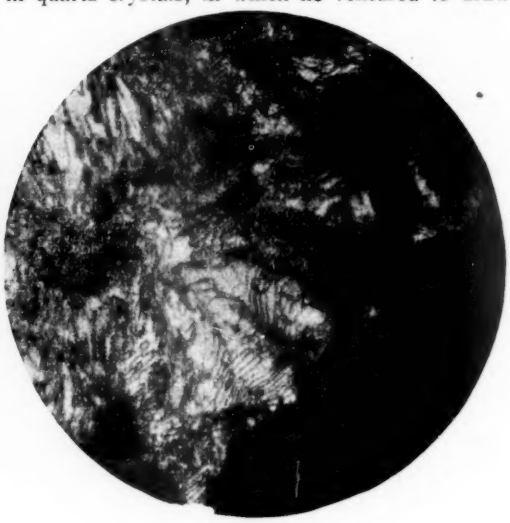

FIG. 4 Magnification 1500.

FIG. 5.—Magnification 5000.

2 mm. Apochromat. Structure of fine lamellar and sorbitic pearlite. The steel used in this experiment had the following composition: C 0·84, Si 0·30, Mn 0·45, Cr 1·12, Ni 0·12 per cent.

conclusions as to the conditions under which rocks had been formed in Nature from the examination of the minute quantities of liquid enclosed in the microscopic cavities in crystals. The paper was received without enthusiasm, and even with ridicule, so absurd did it seem to study geological problems on the minute scale of the microscope. Nevertheless, Sorby's conclusions came to be accepted by all geologists, and his paper is now accepted as one of the classics of the science. In 1863 he turned his attention to iron and steel, being led to their study by an examination of meteorites. Just as he had fused masses of silicates artificially in an attempt to solve some of the problems connected with igneous rocks, so he proposed to use the information to be derived from artificial masses of iron and steel for the explanation of the characteristics of meteoric irons. He exhibited sections of iron and steel, and photographs taken from them, at Sheffield and also at the Bath meeting of the British Association in 1864, and even these early photographs, taken, of

course, at low magnifications, leave little to be desired in regard to sharpness and beauty. A collection of Sorby's original polished and etched sections of metals is carefully preserved by the University of Sheffield, and was lent on the occasion of the symposium.

Sorby's discovery aroused little interest, and when, in 1877, Prof. Martens, of Berlin, soon followed by Osmond and by Le Chatelier in Paris, began the study of metals with the aid of the microscope, the work of their predecessor had been forgotten. By this time, however, a general interest in the subject had been awakened, and Sorby's important papers in the Journal of the Iron and Steel Institute in 1886 and 1887 met with a more appreciative audience. By employing higher magnifications, Sorby was able to show that the "pearly constituent" of steel, as he had called one of its principal constituents, owing to the mother-of-pearl lustre often exhibited by it, was in reality an aggregate of parallel plates of a soft and a hard material. This discovery placed the metallography of steel on a firm basis, and prepared the way for the complete explanation of its structure when thermal methods were added to those of the microscope. Great as were the services of other investigators, it is to Sorby that we owe, without question, our modern metallographic methods.

Sorby laid great stress on the extension of our knowledge by the use of higher magnifying powers, so well illustrated by his own discovery of the true nature of pearlite. Most metallographic work is done at magnifications not exceeding 500 diameters, but excellent results have been obtained by some workers with magnifications of 1000 and even of 1500 diameters. The minuteness of many metallic structures, especially those of hardened and tempered steels, has made many metallographers wish for a means of applying much higher magnifications. Since the discovery of new detail depends, not on the magnifying power, but on the resolving power of the microscope, it is necessary to increase the latter. This may be effected either by increasing the numerical aperture of the objective, or by shortening the wave-length of the light used for illumination. The numerical aperture can be increased beyond its present maximum only by the use of other materials than glass, a plan which is likely to be adopted at some future time, whilst the use of ultra-violet light, the magnificent results of which in bacteriology were shown at the meeting by Mr. J. E. Barnard, has so far given disappointing results with metals.

A valuable contribution to the study of highly magnified metal sections was made by the third paper under notice, that by Sir Robert Hadfield and Mr. T. G. Elliot. The numerous and very beautiful plates illustrate both the advantages of high magnifications and the pitfalls which have to be avoided if success is to be obtained. For example, a field containing ferrite and pearlite is shown in three photographs, all taken at a magnification of 600 diameters, but with objectives of different resolving power. With a 12-mm. objective, the pearlite is structureless (Fig. 1), and only when a 2-mm. apochromat is used is its minute lamination fully revealed (Fig. 2). Another pearlite has its structure revealed at 1500 diam. (Fig. 4), but becomes much clearer at 5000 (Fig. 5), using the same objective. No further advantage is shown at 8000 diam. The effect of narrowing the aperture too much is shown by the apparent broadening of the cementite lamellæ in the pearlite, the true breadth being seen very clearly when the iris diaphragm is opened sufficiently. The photographs, all of which are remarkably good, may be said to be most successful in the case of pearlitic structures. The structure of martensite at 5000 diam. is not so clearly seen as at a much lower magnification, whilst the minutely granular structures of troostite and sorbite evidently call for a higher resolving power rather than for mere enlargement to indicate their true nature. The paper will serve a most useful purpose in directing attention to the nature of the problem, and perhaps attracting skilled optical workers and physicists to its solution.

C. H. D.

REPORT OF THE CALCUTTA UNIVERSITY COMMISSION.[1]

AT first sight a report in five volumes, each of upwards of four hundred pages, on the Calcutta University Commission would appear somewhat portentous; but anyone alive to the importance of university education in India who makes a study of these volumes will be quickly reconciled to their length and number. For it may be fairly claimed that they contain scarcely a sentence which one would desire to see omitted. The whole report of the Commission, including evidence and appendices, comprises no fewer than thirteen volumes, but we are here concerned only with the first five. Vols. i., ii., and iii. contain a very masterly analysis of the present conditions of education obtaining in Bengal, and vols. iv. and v. the actual recommendations of the Commission.

Although this report ostensibly deals only with education in Bengal, the greater part of it naturally has bearing on our educational systems throughout India. The whole report is a model of style, and bears testimony to the infinite pains and care taken by its editors. The names of the members of the Commission were a sufficient guarantee of its thoroughness and accuracy. The review of the present conditions of education in Bengal constitutes in itself one of the most valuable documents for the student of British rule in India. Reports, annual and quinquennial, have been issued in quantity from the various secretariats in India, but we know of nothing to compare for thoroughness and instructiveness with the chapters under review.

It is, of course, impossible for us in this place to do more than refer briefly to one or two of

[1] Reports of the Calcutta University Commission, 1917-19. (Calcutta Superintendent Government Printing, India, 1919.) Prices: Vol. i., Part i. 3s.; Vol. ii., Part i., 3s. 6d.; Vol. iii., Part i., 1s. 6d.; Vol. iv., Part ii., 2s. 6d.; Vol. v., Part ii., 2s.

the many important topics dealt with, but before discussing any of these we may mention that the key to the reforms recommended by the Commissioners is the establishment of a Board of Secondary and Intermediate Education. The object they have in view is to secure the admission of students to the university who are duly prepared for higher studies, and the exclusion of those who are not. Under existing conditions an enormous number of candidates are sent up for the matriculation examination who are totally unfit to enter on university studies.

There are, of course, a number of excellent high schools in Bengal, and especially in Calcutta, but there are a far greater number of inferior schools. Their inferiority is due in a great measure to the low standard of the teaching staff. English, for example, is often taught by an Indian on a poor salary, who is not really qualified to teach it. As the time approaches for the matriculation examination, a test examination is held in each school, and on the result of that test candidates are allowed to go in for the university examination. A percentage of marks is demanded of students who are allowed to proceed, but the test varies very much from school to school, and owing to the solicitations of parents and other causes there is a tendency to show great leniency, for so important is the prestige attaching to higher English education that to have failed in the matriculation is already regarded as an achievement. All Anglo-Indians are familiar with the claims that are supposed to attach to a man who has failed in the B.A., his value in the marriage-market being far greater than that of a man who has not sat for the B.A. at all.

The main problems, therefore, which the Commission set itself to solve were: (1) how to improve the higher classes of the secondary schools, and (2) how to secure the admission only of qualified students to university courses. Having convinced themselves of the impossibility of exercising full control of all the secondary schools in the province, which would involve an extensive inspectorate and interference with many private enterprises, the Commissioners came to the conclusion that control could be exercised at the stage now represented by the intermediate stage at universities, and they therefore suggest the establishment of intermediate colleges, which should be either attached to selected high schools or organised as distinct institutions. These colleges should be under the immediate control of the Board of Secondary and Intermediate Education, the constitution of which is representative of all classes. The intermediate colleges should afford instruction not only for the ordinary degree courses of the university in arts and science, but also for the medical, engineering, and teaching professions, and for careers in agriculture, commerce, and industry. There should be two secondary-school examinations: the first, approximately corresponding to the present matriculation, to be taken at the end of the high-school stage, at the normal age of sixteen, or, in special cases, at the age of fifteen, and to be known as the high-school examination; the second, approximately corresponding to the present intermediate, but much more varied in its range, to be taken at the end of the intermediate college course, at the normal age of eighteen, and to be known as the intermediate college examination. Success in this examination should constitute the normal test of admission to university courses.

The constitution of the board is, of course, a very important matter. It is to consist of from fifteen to eighteen members, with power to appoint outside members to sub-committees. The president of the board should be a salaried official appointed by Government, of high status. This board will naturally take a good deal of responsibility out of the hands of the universities, which will, however, be represented on it by seven members, for they will define the curricula, not only of the intermediate colleges, but, as naturally follows, also of the high schools; and they will further conduct the two secondary-school examinations which we have mentioned above. This board will also, of course, relieve the Director of Public Instruction of much detail work, without, however, reducing in any way the importance of his department.

Such is the Commission's proposal for improving the system. The Commissioners have also gone very thoroughly into the all-important question of improving the teaching staffs, which is chiefly a matter of finance. In this connection they have made several important proposals, of which the three following are the most important: (1) That facilities should be given for the interchange of teachers between privately managed schools and Government schools; (2) that teachers in Government schools and colleges should be placed upon a professional rather than a service basis; (3) that a superannuation fund should be instituted to replace the existing pension system for future recruits to the profession. This last suggestion, which is based upon the federated superannuation scheme which has been adopted in the home universities, should do much to encourage recruiting for the Bengal educational service.

One of the most difficult subjects with which the Commission has had to deal was the question of the medium of instruction to be used in secondary schools. Although, as is natural, there is a general desire among Indians that their children should be educated on a bilingual basis, there is an overwhelming mass of opinion in favour of English as the chief medium from the intermediate stage upwards. The difficulty is to decide at what stage to begin to use English as a medium, and for what subjects. The Commission is of opinion that the vernacular should be used for instruction throughout secondary schools for all subjects other than English and mathematics. It was convinced that the use of English in secondary schools as a medium is excessive. The Commissioners are, however, "emphatically of opinion that there is something unsound in a system of

education which leaves a young man, at the conclusion of his course, unable to speak or write his own mother tongue fluently and correctly."

There is, we are aware, an ever-increasing desire on the part of Indians to see the vernaculars encouraged and developed; for a long time Englishmen also have aimed at fostering the development of vernacular literatures, and post-graduate research in the vernaculars is already a recognised branch of study. But it is, we feel, important to keep distinct the two objects in view, namely, (1) to provide the best education for schoolboys, and (2) to cultivate the vernacular languages.

Space will not permit us to discuss at any length the cognate subject of the teaching of English, but it may fairly be claimed that hitherto university instruction in English has been conducted on unpractical lines. Textual analysis of seventeenth-century literature on the part of students who have not mastered the modern idiom tends to unintelligent cram. What is wanted is the more rapid perusal of standard modern works. Nothing can be more pitiable than to see a class of Indian students taking down verbatim notes (always in English) from a lecturer on such a book as "Samson Agonistes." This is not the way to learn English for practical purposes, which is the main object of all except those who take English as a subject for their degree. It is satisfactory to note that the Sanskrit College and the Madrasahs have received ample treatment by the Commission, and are to be placed on a better footing.

We have not space to deal now with the important proposals of the Commission in regard to the organisation of the University of Dacca, the reorganisation of the University of Calcutta, and their many recommendations in regard to examinations, women's education, medical education, agricultural education, engineering and technological education, and Oriental studies. We can only congratulate the Commissioners on the admirable report they have produced, and express a hope that their main proposal, the Board of Secondary and Intermediate Education, may become before long a practical reality.

E. DENISON ROSS.

NOTES.

ONE of the most useful functions that can be performed in these days of minute specialisation of scientific research is the promotion of meetings at which workers in various fields can discuss subjects of common interest. Since Sir Robert Hadfield became president of the Faraday Society in 1914, fifteen such discussions have been held, the last, of which an account is given elsewhere in this issue, being in the meeting-room of the Royal Society on January 14, in association with the Royal Microscopical Society, the Optical Society, and the Photomicrographic Society. Sir Robert Hadfield and the secretary of the Faraday Society, Mr. F. S. Spiers, are to be heartily congratulated upon the great interest taken in this discussion, the subject of which was "The Microscope: Its Design, Construction, and Applications," and the exhibition of instruments connected with it. There were meetings in the afternoon and evening, and on both occasions it is scarcely too much to say that as many people were unable to find places in the meeting-room as those who filled it to the doors. With characteristic generosity Sir Robert Hadfield entertained a large company to dinner at the Ritz Hotel between the two meetings. The whole session was most successful and encouraging to all who are interested in the advance of British optical science, both theoretical and applied. By organising such joint meetings the Faraday Society is indeed promoting the best interests of both science and industry, and doing what might be undertaken even more appropriately by the Royal Society itself.

AN interesting pamphlet on the work of Faraday and the Faraday Society was prepared by Sir Robert Hadfield in connection with the joint discussion on the microscope held on Wednesday, January 14. It appears that the Faraday Society was chiefly responsible for the appointment of a special Nitrogen Products Committee by the Munitions Inventions Department, and this Committee was, in turn, instrumental in establishing a research department, which provided much valuable information for the practical consideration of sources of nitrogen supply when the submarine campaign made the subject a matter of national concern. One of the members of the council of the society, Dr. J. A. Harker, was entrusted with the direction of this work, and the final report of the Nitrogen Products Committee, which has just been published (Cmd. 482, 4s. net), is a most substantial survey of the position of supplies of nitrogen compounds and the practical problems involved in the establishment of processes for nitrogen fixation in this country. Referring in the pamphlet to his own particular lines of work, Sir Robert Hadfield mentions that Faraday, in his experiments on alloys of iron with other elements carried out in 1821 and 1822, was the pioneer of the great technical advances which have been made in alloy steels during the past thirty years. It was Sir Robert's own discovery and invention of manganese steel in 1882 which led others to explore the rich field first entered by Faraday, and has resulted in the production of chromium steel, silicon steel, nickel steel, tungsten steel, and many other types.

THE recent death of Dr. John Wilson, lecturer in agriculture and rural economy in the University of St. Andrews, robs the University and science of a keen and brilliant agricultural biologist. Dr. Wilson was one of the few who regarded agriculture as a sister science of biology rather than as a branch of chemistry, and his work on the improvement of farm crops has borne excellent fruit. Whilst demonstrator in zoology he devoted considerable attention to the development of the common mussel, and published an elaborately illustrated memoir on the subject, but his name will be more permanently associated with his successful investigations on the improvement of such plants as the potato, turnip, and oat. He raised an enormous number of new varieties. Amongst those

of the potato were many of exceedingly fine quality and disease-resisting properties, and they have been taken up by growers all over the country. His most successful varieties in this connection were perhaps Templar, Bishop, and Rector. Dr. Wilson's experimental work on oats was equally successful, and he was hoping shortly to place on record a full account of his investigations. Many other plants at different times claimed his attention with equally interesting results. Handicapped by lack of means and assistance, he never spared himself. His unflagging enthusiasm and remarkable energy deserved better and more liberal support, and had it been forthcoming there is not the slightest doubt that the nation would have greatly benefited by his researches.

FATHER JOHANN NEPOMUK STRASSMAIER, S.J., the distinguished Assyriologist, who died on January 11 at the Jesuits' Church, Mount Street, London, W., was born in Bavaria in 1846. Soon after the beginning of Bismarck's *Kulturkampf* against the Catholic Church in Germany, Strassmaier left his native land in 1872 and came to England, where he remained for the rest of his life. From his early youth he had been deeply interested in Oriental studies, and in London his attention was soon directed to the numerous Babylonian tablets in the British Museum, which had not yet been interpreted and translated, and among which were many astronomical texts. Strassmaier was fortunate enough to become associated with Father Epping, S.J., who undertook the necessary calculations and the scientific discussion of the texts interpreted by Strassmaier. The first results of their labours were published in a book, "Astronomisches aus Babylon" (1889), which was followed by several papers in the *Zeitschrift für Assyriologie*. They showed clearly that the astronomers of Babylon during the two or three centuries before Hipparchus (if not earlier) possessed a considerable amount of accurate knowledge of the motions of the sun, moon, and planets. Epping died about 1895, but some years later his work was taken up by Father Kugler, who published his "Babylonische Mondrechnung" in 1900, and began to issue his great work, "Sternkunde und Sterndienst in Babel," in 1907. Kugler repeatedly bore testimony to the great patience and skill of Strassmaier in deciphering many text, which but for him might have remained unread for ever, as they were gradually deteriorating owing to damp and other climatic influences.

THE Lord President of the Council has approved the appointment of Col. Sir Frederic Nathan, K.B.E., late R.A., to be Power Alcohol Investigation Officer under the Fuel Research Board of the Department of Scientific and Industrial Research. The appointment of the Power Alcohol Investigation Officer has been made as a result of the consideration given by the Committee of Council for Scientific and Industrial Research to the report of the Interdepartmental Committee on the Production and Utilisation of Alcohol for Power and Traction Purposes, which recommended the establishment of a small permanent organisation under the Department of Scientific and Industrial Research to continue investigations into these problems. The Fuel Research Board proposes to begin by bringing the work already being done as regards both the production and the utilisation of alcohol into proper focus. Sir Frederic Nathan, who before the war was Superintendent of the Royal Gunpowder Factory at Waltham Abbey, and later works manager of Messrs. Nobel's Explosives Factory, Ardeer, was the officer in control of alcohol under the Ministry of Munitions during the war, and chairman of the Production Section of the Interdepartmental Committee referred to above. Prof. Pierce Purcell, who was Secretary of the Irish Peat Inquiry Committee, has also been appointed to act as Peat Investigation Officer under the Fuel Research Board. The duties of the Peat Investigation Officer will be to keep the Board informed of all progress in connection with research into the utilisation of peat, to continue and extend experiments on the mechanical cutting and winning of peat, and to make arrangements for careful tests of the use of peat as a fuel under boilers.

PROF. R. T. LEIPER, reader in helminthology in the University of London, has been awarded the Straits Settlement gold medal by the Senate of the University of Glasgow. The medal was founded some years ago by Scottish medical practitioners in the Malay States, and is given periodically to a graduate in medicine of the Scottish universities for a thesis on a subject of tropical medicine.

THE council of the British Medical Association is prepared to consider an award of the Middlemore prize (value 50*l*.) and an illuminated certificate for the best essay on "Perimetry (inclusive of Scotometry): Its Methods and its Value to the Ophthalmic Surgeon." The competing essays must reach the Medical Secretary of the Association, 429 Strand, W.C.2, on or before April 30 next.

MR. C. T. KINGZETT writes to suggest that airmen rising to great altitudes should carry bottles of water which, by being emptied at such heights, could then be sealed, and would enable samples of the air there to be secured for purposes of analysis. The late M. Teisserenc de Bort obtained specimens in this way and had them analysed, but found no difference from normal air. His specimens were obtained from registering balloons beyond the reach of any manned balloon or aeroplane. Glaisher no doubt also obtained air from the highest points he reached in his ascents about 1862.

THE death of Mr. Alexander Izat on January 2 is announced in *Engineering* for January 16. Mr. Izat joined the Indian Public Works Department in 1863, and had much to do with the development of the Indian railways. For several years he was on the Legislative Council of the Lieutenant-Governor of the United Provinces; he was made a Companion of the Indian Empire in 1898, and served for several years as a member of council of the Institution of Civil Engineers. At the time of his death he was in his seventy-sixth year.

WE learn with regret that Prof. George Macloskie, professor of biology, Princeton University, U.S.A., died on January 4 in the eighty-fifth year of his age. Prof. Macloskie was born at Castledawson, Ireland,

and educated at Queen's University, Belfast, from which he received degrees in both law and theology. During his student days he was twice a gold medallist of the college. He was called to Princeton in 1875, during the administration of President McCosh. Since 1907 Prof. Macloskie had been professor emeritus of biology in Princeton University. He is best known for his work on the flora of Patagonia.

THE *Times* of January 21 contains the following announcement with reference to the Dartmoor hydro-electric supply scheme:—"In deference to the opposition from the Duchy of Cornwall and the Devon County Council, the promoters have decided to drop that part of the Hydro-electric Bill by which they sought to utilise Dartmoor water for generating electricity. They will modify the Bill to restrict their powers to erecting overhead mains for supplying to consumers such surplus power beyond the requirements of their proposed copper-refining industry in mid-Devon, which they produce from lignite beds they intend to develop."

STRONG earthquakes continue to be felt in Mexico. At La Fragua, in the State of Puebla, shocks have been almost continuous since the great earthquake of January 3. At Coatzlan, another shock occurred on January 9, by which the destruction of the town was completed. San Joaquin, a village of 3000 inhabitants in the State of Vera Cruz, was destroyed by an earthquake on the morning of January 12. On January 8 the volcano of San Miguel, 35 miles north-east of Cordoba, broke into eruption; streams of lava flowed down the south-east side of the mountain, destroying villages and ranches.

ACCORDING to the Bulletin of the Science Division of the Royal Academy of Belgium for March, 1919, at the meeting on March 1 it was decided:—(1) To break off relations and exchange of publications with the scientific societies of Germany, Austria, Hungary, and Turkey. (2) To employ only booksellers to procure such publications as shall be considered strictly necessary, whatever be the additional cost involved. (3) Not to send any publication to the men of science of the above nations. (4) To decline and return to the societies or authors of the above countries any publications sent to the academy.

AN interesting interview with Prof. Einstein appeared in the *Daily Chronicle* of January 15. A German by birth, Prof. Einstein went to Switzerland in his early youth, where he became naturalised. For some years he was professor of physics at the Federal Polytechnikum in Zürich, and for a short time also at the University of Prague. Shortly before the outbreak of war he was "called" to the University of Berlin, where he is still working, being at the same time director of the Kaiser Wilhelm Institute for Physical Research. Now little more than forty years of age, this eminent man of science conceived the outlines of the theory of relativity at the early age of eighteen, and presented his special theory to the scientific world at the age of twenty-seven. Prof. Einstein regards Prof. Lorentz (Leyden) as his "co-operator" in the special theory of relativity. He points out that, far from vitiating the results of Newton, the theory of relativity rather enhances the greatness of this genius. Though these new ideas will not overthrow the general conceptions of mankind, they will leave their impress on men's thinking in the philosophical and allied sciences.

FOR some years there has been a vigorous Phytopathological Society in the United States, and recently a Canadian branch of this has been formed, the first annual meeting being held in Ontario. Dr. A. H. R. Buller, formerly of Birmingham University, and now professor of botany in the University of Manitoba, was elected president for 1920. Dr. E. C. Stakman, of Minnesota, was the guest of the society, and gave an account of the very valuable investigations which he and his colleagues have carried out into the races of cereal rust fungi and their bearing on the problems of immunity and susceptibility to disease. Among the attractive list of papers presented to the meeting, those of Mr. J. E. Howitt on "Leaf-roll and Mosaic of Potatoes" and of Mr. Paul A. Murphy on "Diseases of Potatoes which Cause the Running Out of Seed" may be mentioned. Both are welcome additions to our very meagre knowledge of extremely obscure subjects of primary importance. There is in this country no society devoting itself exclusively to phytopathology, and perhaps this is well, for we possess already more than enough small specialised organisations running a precarious separate existence. The need is not for increase in their number, but for some kind of amalgamation or federation of those now existent. The study of diseased crops is merely one branch of applied biology, and this subject is excellently catered for by the Association of Economic Biologists, which performs valuable work in synthesising all the many aspects of investigation which centre round the economic utilisation of plants.

POWELL'S classification and map of the linguistic families of America allotted twenty-two families, or parts of families, to California. This classification has hitherto been generally accepted. But in recent years the study of these dialects has been fully investigated by Messrs. R. B. Dixon and A. L. Kroeber, the results of their work being now published in the University of California Publications in American Archæology and Ethnology (vol. xviii., No. 3, September, 1919). It has now become possible to regroup these dialects into seven main groups. The most important of these are the Penutian in the north-western region and the Uto-Aztekan to the south-west. The remaining language-groups form a sort of fringe round the two greater groups, the most important being the Hokon, and of less extent the Algonkin, Athabaskan, Yokian, and Lutuamian. Full grammatical details on which this new classification is based are given by Messrs. Dixon and Kroeber.

MR. J. W. GOWEN has made (*Genetics*, May, 1919) a biometrical study of the phenomenon of heredity known as crossing-over, basing his conclusions on extensive data derived from the behaviour of the Mendelian factors in the third chromosome of *Drosophila melanogaster*. It is shown that double crossing-

over is an extremely variable phenomenon. The reduplication hypothesis is regarded as definitely disproved, and all detailed interpretations are based upon the structure of the chromosomes. Crossing-over between two fixed points on a chromosome is found to be highly variable. It is also found that a change in genes between two fixed points in the third chromosome slightly disturbs the ratios of crossing-over between those points. Biometric analysis shows that the results are all in harmony with the hypothesis that the factors are represented by particles arranged along the chromosomes. A cross-over in one region of the chromosome is more likely to be accompanied by a cross-over 25–35 units away than elsewhere.

VOL. ix. of the *Bulletin Statistique* has just been published by the International Council for Fishery Investigations. Particular interest attaches to this report, as it deals with the year 1913, the last of a long series during which there has been a continuous, progressive development of the sea-fishing industry in North European countries, and vol. ix. is likely to remain a standard of comparison of two periods, in the interval between which many conditions will be found greatly to have changed. The council has in preparation a Bulletin describing the effect of the war upon the fisheries, and this, it is hoped, will soon be ready. Several changes have been made in the arrangement of the present volume; the use of two languages has been dropped, and the results are now published only in English. There are many useful diagrams. A feature of exceedingly great interest, the estimation of the capital employed industrially, in factories, curing works, etc., in 1913, as well as in the vessels, might be included in the next volume as a help to the understanding of the great change in economic conditions that is now taking place.

THE Tôhoku Imperial University, Sendai, Japan, continues to publish beautifully illustrated memoirs on fossils in the geological series of its Science Reports. In the latest part received (vol. v., No. 1), Mr. I. Hayasaka describes the microscopical structure of three Permian species of the remarkable sponge Amblysiphonella from Japan and China. Prof. H. Yabe also illustrates in three fine plates the microscopical structure of a Tertiary foraminiferal limestone from Borneo.

THE United States Geological Survey has published Professional Papers Nos. 112 and 120, dealing respectively with Cretaceous plant-remains from Tennessee, Mississippi, Alabama, and Georgia, and Cretaceous fish-scales from various American localities. The plant-remains, described by Dr. E. W. Berry, are chiefly leaves of dicotyledons, and represent a lowland coast flora. The sudden appearance of dicotyledons as the dominant plants in Middle Cretaceous times is still a mystery, and Dr. Berry thinks this modern flora may have originated in the Arctic regions. The description of the fish-scales by Prof. T. D. A. Cockerell is a bold attempt to use fragmentary fossils in stratigraphical geology.

PART iii. of vol. iv. of the Records of the Geological Survey of India, which has just reached us, contains a review of the mineral production of India during 1918. Upon the whole the position is satisfactory, most of the important minerals showing an increased production. Thus the coal output rose from 18,212,918 to 20,721,543 tons; it is worth noting that the most substantial increases are shown in the important coalfields of Jharia and Raniganj, which produced respectively 52·85 per cent. and 30·74 per cent. of the total Indian output. The output of iron ore, too, increased, namely, from 413,273 to 492,484 tons, most of which was smelted in the works of the Tata Iron and Steel Co. and the Bengal Iron and Steel Co.; the latter produced also 12,114 tons of ferro-manganese during the year under review. There was a large increase in the production of chromite, mainly through the development of some recent discoveries in the State of Mysore. The output of manganese ore, on the other hand, fell from 591,000 to 518,000 tons, the falling off being probably caused by the difficulties of procuring the necessary shipping facilities. The Bawdwin mine in the Northern Shan States again shows an increase of output, namely, 19,074 tons of lead and 1,970,614 oz. of silver, as against 16,962 tons of lead and 1,580,557 oz. of silver. Gold, on the other hand, declined somewhat, namely, from 574,293 oz. to 536,118 oz. The falling off under this head has, of course, a far less effect upon the prosperity of India than has the increase noted under such minerals as coal and iron, which contribute essentially to the industrial development of the country.

THE oscillations in the luminosity of incandescent electric lamps illuminated by alternating currents forms the subject of a short report by Dr. Luigino Fabaro in the *Atti dei Lincei* (xxviii. (1), 7, 8). The phenomena had been previously studied by Prof. Corbino, and the present experiments refer mainly to certain recent types of lamp. Diagrams are drawn showing the relation between the fluctuations of intensity and those of the electromotive force, and, at the same time, the difference of phase between the luminosity and the exciting electromotive force. These are in conformity with the theory that the effect can be reduced by increasing the mass of the filament.

FROM the Laboratorio di Ottica pratica e Meccanica di Precisione we have received the first numbers of a new periodical, *Rivista d'Ottica e Meccanica di Precisione*. Hitherto Italy has not had a technical periodical on the lines of the German *Zeitschrift für Instrumentenkunde*, and the new journal is a modest attempt to fill the want. Like other countries, Italy has made great progress in the construction of optical and other scientific instruments during the war, and the need for a medium in which matters of interest to practical optical workers can be discussed is now being felt. The November–December number contains articles on Galileo and the pendulum clock, the application of interference methods over simple observations with the naked eye, the first instalment of a paper by P. G. Nutting on "Dispersion

Formulæ for Optical Glass," and a description of the focimeter of the Royal Precision Laboratory, as well as a selection of abstracts from foreign periodicals.

IN an article entitled "The Æther *versus* Relativity" in the January issue of the *Fortnightly Review* Sir Oliver Lodge contends that as the current ideas that the æther is an infinitely extended uniform medium as a whole at rest, and that absolute motion is to be measured with respect to this æther, are simple and straightforward, they should be retained so long as no clear proof that they are false is forthcoming. The new theories express the facts of experience in other terms, but they attribute the property of wave-transmission to geometrical space free from any medium, and are, in consequence, repugnant to those "with a competent faculty for rational philosophising." Sir Oliver Lodge urges the desirability of comparing the speeds of light along and against a strong magnetic field as a promising means of determining the density of the æther. Such a result would entirely discredit the theory of relativity as a statement of real fact.

A REPORT on the general theory of blade-screws, forming Report No. 9 of the American National Advisory Committee for Aeronautics, has been drawn up by Mr. George de Bothezat, of Dayton, Ohio (Washington: Government Printing Office, 1919). In a problem like the present, in which the conditions are far too complex to admit of an exact hydrodynamical solution, any theory necessarily involves assumptions which at best are only approximate. The author applies elemental methods, first, to the slip stream, and, secondly, to the region surrounding a blade element, and, in common with many previous investigations, neglect of the effects of radial motion is one of the assumptions made in a first approximation. The theory appears to constitute an advance on previous investigations, especially in the matter of a detailed examination of the elements of fluid, and the author is very careful in stating the assumptions on which the work is based, and the justification for which will necessarily depend on comparison of the results with those of experiment. An appendix deals with the geometry of screw-blade drawing. The method appears to neglect compressibility, and will therefore be applicable to air-screws of which the tip velocity does not come too near the velocity of sound.

AN important paper on radio-transmission and reception by Mr. J. H. Dellinger has been published by the Bureau of Standards, Washington. The difficulty experienced by practically every man of science in understanding the ordinary radio theory is in mastering the proof of the formula which gives the magnetic force at a distance from the sending antenna in terms of the wave-length of the radiation. He objects to accepting it without proof, and he has not time to puzzle out the intricate theory given by Hertz. Mr. Dellinger gives a rough proof of this formula based on well-known laws. This formula being accepted, the rest of radio theory follows very simply. The formula has been tested in practice many times, and found accurate within a small percentage of error. The author makes a theoretical comparison of the relative values of antennæ and closed coils for sending and receiving purposes, and it is shown how the limitations of each follow directly from theory. Although the theory is sufficiently accurate to be a great help in the design of radio stations, yet the necessity for further research, both experimental and theoretical, is urgent, and a long list of such researches is suggested. To everyone desiring a knowledge of the practical theory of radio communication this paper can be recommended.

THE lot of the inventor is always hard unless he is exceptionally placed, and combines commercial with inventive ability. *Engineering* for January 9 points out two ways in which it is becoming increasingly difficult. Experiment is becoming much more costly, and at the same time the protection afforded by the patent laws becomes less and less. Nevertheless, the essential importance of invention from the national point of view is now recognised, and research laboratories are being set up which are to afford every facility for experiment. The success of this movement depends upon getting the inventors into the laboratories, and upon their doing their best work when they are there. But we find that men entering these laboratories are being required to sign away all rights of every kind to any invention they may make. They are to rely solely upon a reward at the discretion of the firm. Our contemporary suggests that a research laboratory should be an independent organisation, financed by the parent firm, but receiving royalties on a liberal scale to be divided among its members by agreement among themselves, and also hints that it may be useless to put forward such a scheme. Apart from the fact that the British business man feels that he is less and less "master in his own house," there is the other point which appeals to research workers, viz. victimisation; he may find himself no longer required in the laboratory, and, after his discharge, may look in vain for his share of the royalties.

Engineering for January 9 contains an article on works management by Mr. F. C. Van Dyke, which will be found to give a very clear discussion of the principles involved. There is a growing tendency to demand that the works manager should be a college-trained engineer, but it is essential that he should have the same practical and varied engineering experience as is required from the self-made man; whatever may have been his initial training, however, mere opportunity without fitness will not produce the successful works manager. The requirements as regards his principles and education may be summarised as consisting essentially of organisation, foresight, co-ordination, supervision or control, and diplomacy. A works manager should recognise that, notwithstanding scientific effort and research, the efficiency given by plant and machines is regulated by human effort, wasteful by instinct, and that to obtain the reduction of such waste it will be necessary to save lost efforts, so that the recovery of waste may add new resources to the community. He must also understand that science in industry will generally be resented by the

average worker. Owing to the workers' insufficient knowledge of the economics ruling industry, he believes that the extra profit thereby derived passes to the employer without relative advantage to the worker, and that the efficiency of employees penalises others by unemployment; hence scientific improvements must be introduced with foresight and tact.

AMONG forthcoming books we notice the following: "Wireless Telegraphy, with Special Reference to the Quenched-spark System," B. Leggett; "Aeronautical Engineers," Major A. Graham Clark; "Theory and Practice of Aeroplane Design," S. T. G. Andrews and S. F. Benson; "Physical Chemistry of the Metals," R. Schenk, translated by R. S. Dean; "Manufacture and Uses of Alloy Steels," H. D. Hibbard; and "Mathematics for Engineers," W. N. Rose, vol. ii. (*Chapman and Hall, Ltd.*); "The Principles of Anatomy as Seen in the Hand," Prof. F. Wood-Jones, illustrated; "A Text-book of Organic Chemistry," E. de Barry Barnett, illustrated; and "Laboratory Manual of Elementary Colloid Chemistry," E. Hatschek, illustrated (*J. and A. Churchill*); "Coal Economy: For Steam Users, Engineers, Enginemen, Boiler Firemen, etc.," W. H. Casmey, and "The Mineralogy of the Rarer Metals," Cahen and Wootton, second edition (*C. Griffin and Co., Ltd.*).

THE new list of announcements of *Mr. John Murray* contains many books of scientific interest, *e.g.* "Science and Life: Aberdeen Addresses," Prof. F. Soddy; "Springtime, and Other Essays," Sir Francis Darwin, illustrated (this week); "Splendours of the Sky," Isabel M. Lewis, illustrated; "Conifers and their Characteristics," C. Coltman-Rogers, illustrated; "Life of Sir William White, K.C.B., F.R.S.," F. Manning, illustrated; "New Light on Ser Marco Polo," Prof. H. Cordier (a supplement to Sir Henry Yule's "The Book of Ser Marco Polo"); "The Shibboleths of Tuberculosis," Dr. M. Paterson; "Wild Life in Canada," Capt. A. Buchanan, illustrated; "The Heron of Castle Creek, and Other Sketches of Bird Life," A. W. Rees, with a memoir of the author by J. K. Hudson, illustrated; volumes dealing respectively with Hides and Skins, Rice, and Oil Seed (in the Imperial Institute Reports on Indian Raw Materials), and "Tungsten Ores," R. H. Rastall and W. H. Wilcockson (in the Imperial Institute Monographs on Mineral Resources); also new editions of "The Interpretation of Radium and the Structure of the Atom," Prof. F. Soddy, illustrated; "Microscopy: The Construction, Theory, and Use of the Microscope," E. J. Spitta, illustrated; "Hydrographical Surveying," the late Rear-Admiral Sir W. J. L. Wharton, revised, etc., by Admiral Sir Mostyn Field; "The Soil," Sir A. D. Hall; and "The Small Farm and its Management," J. Long.

OUR ASTRONOMICAL COLUMN.

LARGE FIREBALL ON JANUARY 16.—In the evening twilight of January 16, at 4h. 50m., a fireball was observed from London and other places in the Eastern Counties. It gave a brilliant flash and left a luminous trail which assumed curious forms during fully 5½ minutes. The observations already received of this object are not sufficiently exact or numerous to allow the real path to be trustworthily determined, but the meteor probably had a radiant in Cygnus at about 290°+53°, and was situated over Lincolnshire. We hope to give more details next week.

In recent years January has proved itself a month in which fireballs are notably abundant. In 1895, on January 16, three large fireballs were observed, and the period from January 12 to 17 seems to have been unusually productive of these brilliant objects.

PROF. W. H. PICKERING'S LUNAR STUDIES.—Prof. W. H. Pickering has for many years made careful studies of various regions of the moon during the whole period of their illumination by the sun. He has traced several cases of notable changes of relative illumination of adjacent regions, some growing brighter, others darkening, as the sun rises higher. *Popular Astronomy* for November contains a number of drawings and photographs of the crater Eratosthenes. The author suggests that the white regions are snow, and the dark regions some low form of vegetation. He imagines that a limited amount of water may remain in certain regions, being held in the soil by capillary attraction. It seems, however, that the phenomena might be otherwise explained by neighbouring regions being formed of different kinds of rock, or even by their being of different degrees of smoothness. Observations of occultations made on the dark limb show with certainty that no refraction occurs exceeding 1″; those made on the bright limb are less precise, but even there the greatest admissible refraction is some 4″. Comparing this with the 68′ of a tangential ray in our atmosphere, we see how exceedingly rare any lunar atmosphere must be. The suggestion of vegetation is perhaps not absolutely impossible, but presents grave difficulties.

With regard to the suggestion made in a publication of the Smithsonian Institution, Washington, D.C., of a rocket to reach the moon, irresistibly recalling the well-known romance of Jules Verne, it seems clear that the propulsive effect of the escaping gases must be trifling beyond the atmosphere. A velocity of seven miles per second would therefore be required at the limits of the atmosphere, and considerably more evidence is needed before this can be admitted as attainable.

THE SOLAR ECLIPSE OF MAY 29, 1919.—The January number of *Conquest* contains an article by Mr. C. R. Davidson, one of the observers of the eclipse at Sobral, Brazil. It is illustrated by many views of the locality, eclipse camp, and instruments, and gives a clear statement of the problem which the expedition was sent to solve, and of the successful result. A deflection of light amounting to 1·98″ at the sun's limb was indicated by the measures, which is close to the value 1·75″ predicted by Einstein. Photography of the corona and prominences was not part of the aims of the expedition; indeed, the author points out that if the observers could have dispensed with these they would gladly have done so, since they veiled some stars near the sun that would have been very useful. However, a good record of the corona was obtained. Its shape is a blend between maximum and minimum types; it would conform more closely to the latter, save for a large streamer at the South Pole. Mr. Davidson and Mr. Woodman directed attention, at the meeting of the R.A.S. on January 9, to the advisability of repeating the observations, with still greater refinement, at the eclipse of September, 1922. They exhibited a model of a simple form of equatorial mounting, suitable for low latitudes, which would obviate the necessity for employing cœlostats. These are admirably adapted for physical researches, but have some defects in a case where extreme precision of position is required.

SYMPOSIUM ON THE MICROSCOPE.

THE symposium and general discussion on the microscope, held on January 14 by the Faraday Society, the Royal Microscopical Society, the Optical Society, and the Photomicrographic Society, in conjunction with the Optical Committee of the British Science Guild, attracted a very large audience, which the meeting-room of the Royal Society proved quite inadequate to accommodate. The objects of the symposium, as stated by Sir Robert Hadfield in his introductory address, were :—

(*a*) Improvement in the technique of the microscope itself, including its manufacture.

(*b*) Improvement in lenses, including eyepieces and objectives of high power.

(*c*) Improved application of the microscope for research in ferrous and non-ferrous metallurgy.

With such extensive ground to be covered it is not surprising that the programme of papers presented was much longer than could possibly be read during the meeting. Many of these were of great interest, and, as the majority were in type before the meeting, the aims of the symposium might perhaps have been more fully achieved had these been taken as read and the time thus saved utilised for discussion. It will only be possible in the space available for this article to record a few of the more salient points brought forward at the meeting.

Sir Robert Hadfield, who was in the chair, opened the afternoon session by giving a brief history of the microscope and its applications in metallurgy down to the present day. In addition, he contributed papers on the Faraday Society and on the work of Sorby, a bibliography of the chief literature relating to the microscope, and a series of photomicrographs of steel and iron sections at magnifications ranging from 9 up to 8000 diameters. He was followed by the presidents of the various participating societies, by microscope manufacturers, and by other prominent workers, who each dealt with some special aspect of microscopy. Prof. Cheshire indicated the importance of microscope production as a measure of the standing of the optical industry of any country. Other speakers touched on ground which was to a considerable extent traversed by many other contributors. On one subject, at any rate, all the speakers were agreed—the necessity for proper training in the use of the microscope, whether for visual or photographic use. This will be clearly realised by those who note how frequently those with extensive experience in microscopical research refer to the importance of securing proper conditions of illumination. The absence of proper courses in this subject was compared by Sir Herbert Jackson with the very thorough courses now available in spectroscopy. That instruction is needed in our universities in the use of the microscope and in the interpretation of the effect seen—nay, more, in the proper appreciation of optical theory itself—was proved beyond any doubt to the meeting.

Compared with the unanimity on the need for education, there were very marked divergences in the views expressed by nearly all the speakers on detailed matters. Consider, for instance, the desirability of obtaining increased magnification with greater resolving power. Many of the most experienced metallurgists who expressed their views anticipated that any considerable increase in resolving power would be likely to afford clues to some of those problems which to-day are most baffling in the production of metals with specific properties. It is suggested, for instance, that with improvements in the resolving power the mysterious alterations in the mechanical properties of metals brought about by cold working would be explained. The papers abound with examples of the valuable information that has been derived from past increases of aperture; nevertheless, some workers are satisfied that further advantage in this direction is not to be expected, and it is even suggested that the N.A. of objectives has already been increased too greatly.

The same extent of disagreement was shown in discussing the relative merits of British and German stands and lenses. For some purposes, at any rate, very experienced workers give decided preference to the English stand, though this is said to be less convenient for metallurgical work. No stand now made, it was said, is sufficiently rigid to enable the microscope to be changed from the vertical to the horizontal position without disturbing the relative adjustment of the specimen and the optical system. Modern designers were recommended to study Powell's model of 1841 as an admirable example of what is required. One important criticism was to the effect that the materials employed by the British makers were too soft, particularly for such working parts as the racks and pinions, with the result that after a few years all the movements were too loose. In this respect German instruments had been found more satisfactory by some workers, though this was not the experience of all.

As regards objectives, it was not denied that the best home-made products were fully as good as those made abroad, but it was contended that this standard of excellence was reached in a smaller proportion of the objectives produced than in the foreign lenses. The importance of a highly trained test-room staff was emphasised in this connection. It may be noted as a point of interest, mentioned by Mr. F. Twyman, that good objectives have been found to show differences of phase in the emergent wave-front of about one wave-length.

During the meeting it was announced that one or two makers would shortly place upon the market new designs of objectives made from English glasses. It is satisfactory to learn that the different varieties of glass required for these objectives have been produced in this country. To determine how these glasses compare with the German lenses of Zeiss, a committee of expert microscopists was appointed to investigate and issue a report. In view of what was said regarding the general standard reached, it would be as well if this proposal were carried a step further, and it became customary for manufacturers to issue with their objectives a certificate issued, say, by the National Physical Laboratory. If the required standard for a certificate were maintained at a reasonable level, with due regard to periodical improvements, such a system should go far to remove the impression that it is *necessary* to go to Germany for a thoroughly good objective.

There are many other points to which attention might be directed, but for these reference must be made to the printed papers. The apparent lack of enterprise on the part of the manufacturer since the war has, however, been fully explained. He has been busy for the first time in making arrangements for the mass production of microscopes by modern machine methods. This is of the first importance, for in the past few years nearly all the microscopes required for biological work—and this covers possibly as much as 90 per cent. of all microscopes made—have been imported. The hand-made English instrument could not possibly compete either in price or in quality with the machine-made article. Should it be possible to regain a large share of this trade while retaining the best features of the more expensive and elaborate models, the future position of the industry in this country will be assured. It is to be hoped that this development will not be hindered, as was suggested, by lack of capital.

Perhaps the most significant and satisfactory feature of the symposium is that it should have been possible to attract for a meeting which extended from 2.30 to 10.15 so large an audience for the discussion of the microscope and its applications to industry. It is more than doubtful if such interest could have been aroused before the war. The optical industry of the country, it is clear, will not fail to establish itself on a secure footing for want of a market. If the home products reach the necessary standard of perfection and keep abreast of the advances which scientific achievement in whatever field renders possible, the reward is certain. This, we are convinced, needs much more systematic investigation in advance of immediate requirements than has been undertaken in the past, greater readiness to be guided by scientific principles rather than by tradition, and not least the design of instruments with special reference to the accuracy obtainable in the various manufacturing operations by the best machine tools. It is a hopeless enterprise with one scientific adviser to attempt to compete with another firm of similar size which employs twenty such advisers. At present such assistance is difficult to obtain. It devolves upon our universities, no less than upon our manufacturers, to consider where they stand, and to do their part towards the country's well-being by making optics a living subject rather than resting satisfied with the knowledge of a hundred years ago. Research on their part and on that of other institutions is necessary; the field is wide. We look to them for that interest which we have every right to expect.

The afternoon session was preceded by an exhibition of microscopes and auxiliary apparatus. The historical collection of microscopes from the South Kensington Museum was of special interest. New models of microscopes attracted much attention. Messrs. Beck and Swift exhibited models fitted with the changing device they have adopted, and some exhibits by Messrs. W. Watson and Sons were greatly admired. Many other exhibits of much interest were shown, but for particulars of these reference must be made to the catalogue specially prepared for the occasion.

The publication of the proceedings of the symposium will be awaited with interest. We trust that all the papers will be collected into a single volume, and be available as a separate publication for all who have special interests in microscopy.

CONSTRUCTION AND USE OF MICROSCOPES.[1]

A CONSIDERATION of the microscope resolves itself of necessity into two parts, the mechanical and the optical. From the mechanical point of view there are two designs in general use, those referred to as the Continental and the English form of microscope. In the Continental type it has usually been customary to have what is known as the horseshoe foot, mainly, I imagine, because of its ease of construction by mechanical engineering methods; whereas the English design of microscope, which has hitherto been mainly made by hand, is of a more steady type, and the points of support are so distributed as to give more stability to the instrument in any position.

The essential parts of the instrument are a coarse adjustment, to give the body tube a quick motion in the direction of the optic axis, and a fine adjustment, which gives it a much slower motion in the same direction. The tube is adjustable in length, to enable correction to be made for varying thicknesses of cover-glass, although a large number of workers appear to regard it as a ready method of obtaining greater or less magnification, with disastrous effects on the resulting image.

There is only one fixed part of a microscope for biological purposes, and that is the stage. But metallographers require that the stage shall also be adjustable in the direction of the optic axis. The body tube itself should be made so that it can be closed to a length of 140 mm., including any objective-changing device that may be on the nose-piece; and it should be possible to lengthen it to at least 200 mm. or 250 mm. if long-tube objectives are used.

All these adjustments are in the direction of the optic axis of the instrument. Two others are usually provided which are at right angles to this direction—that is, a mechanical stage for actuating the object, and in certain of the best-class instruments an arrangement for centring the sub-stage condenser to the axis of the objective.

While there are many points which might be raised on the mechanical side, there are only one or two that I have time to mention. The main point about most microscopes appears to be that they are unstable. I have a considerable number in my own possession, but I do not think I have one even now which, if I centre an object on the stage with the instrument in a vertical position, still maintains its centration accurately if the instrument is put into the horizontal. The probability is, therefore, that there are few microscopes made at the present time that exactly fulfil the conditions necessary for high-class photomicrographic work or for observational microscopic work of an exacting order. I trust, however, that an instrument exhibited at this symposium will embody the necessary improvements to rectify this matter.

Some misapprehension appears to me also to exist as to the relative purpose of the coarse and the fine adjustments. The coarse adjustment appears to me to be one which should be sufficiently well made, and with which the user is sufficiently expert, to enable him to bring into view any object, whether it is being observed with a low- or a high-power objective. The fine adjustment is then used for accurate focussing and for getting a conception of the object in depth. In biological work, at any rate, this is very rarely the state of affairs as carried out. In using an oil-immersion objective, for instance, a common method is to immerse the objective, and then to lower it so that it all but touches the top surface of the cover-glass. The objective is then raised by means of the fine adjustment until the object comes into view. While this may act fairly well with very thin cover-glasses, it is a haphazard method when cover-glasses of varying thicknesses are used. It should be realised that when microscope-users are sufficiently educated they will be able to tell how far they are from the actual image by the appearance of the light in the field of view—that is, if the object is illuminated with reasonable accuracy.

Mechanical stages also appear to need some consideration. The stages which will on actuation cause no shift of the object other than in the direction intended, or any alteration of focus, are rare. Further, those in which the screws project for a considerable distance, with the result that any slight jar or knock causes them to be displaced, and, it may be, actually bent, are objectionable when used under laboratory conditions.

There is, I think, much to be said for the type of stage which has either co-axial milled heads on a vertical axis, or, if inconvenient to make, milled heads which are on separate axes. This method of con-

[1] Opening paper of a discussion on "The Microscope: Its Design, Construction, and Applications," organised by the Faraday Society and held at the Royal Society on January 14. By J. E. Barnard, president of the Royal Microscopical Society.

struction of necessity results in a much stiffer and more stable stage. There is, in fact, a general lack of stability going through nearly all parts of a microscope. But it is significant that, even so long ago as the beginning of last century, the instrument as then designed had much greater attention paid to this point. The microscope an illustration of which I show on the screen is, to my mind, an embodiment of a principle that should receive attention. So soon as English makers are in a position to consider the production of an instrument of a special type, it is my intention to have one made. In this the general principle is that all the optical parts are carried on a bar which is, in effect, an optical bench, and that this is strutted in such a way as to give stiffness to the instrument as a whole. The only effort that I am aware of that has been made in this direction is in the microscope designed by Dr. Rosenhain, particularly for metallography, but which is adaptable for ordinary work. This instrument, to my mind, is such an improvement on any other type of stand that I am at a loss to understand why metallographers have not more generally taken it up. It might appear that I am exaggerating the importance of stability in the stand, but it should be realised that any lack of centration in the optical parts, or of alignment in the optic axes of these parts, results in more serious deterioration of the resulting microscopic image than any other single factor. The optical parts of a microscope are the objective, for obtaining the primary magnified image of the object; the ocular, for further enlarging that image and transmitting it to the eye; and the sub-stage condenser, for illuminating the object with a larger or smaller cone of light. The limitations of time will prevent me from doing more than refer very briefly to some properties of the optical parts.

It is generally assumed that magnification is the primary function of an objective, but in point of fact the main point is not magnification, but resolution. By resolution is meant the power the objective has of separating and forming correct images of fine detail. The theory known as the Abbe diffraction theory is the one on which modern optical calculations are based; and it is safe to say that it was never more fully accepted than at the present time, and never rested on a surer basis. There has been much discussion in this country of that theory, and probably a good deal of misconception has arisen from its inapt designation, for the term "diffraction theory" is perhaps somewhat unfortunate. I cannot do better than quote the late Lord Rayleigh in reference to this matter. He said: "The special theory initiated by Prof. Abbe is usually called the diffraction theory, a nomenclature against which it is necessary to protest. Whatever may be the view taken, any theory of resolving power of optical instruments must be a diffraction theory in a certain sense, so that the name is not distinctive. Diffraction is more naturally regarded as the obstacle to fine definition, and not, as with some exponents of Prof. Abbe's theory, the machinery by which good definition is brought about." This very clearly and accurately sums up the position. The Abbe theory tells us that there are two main factors determining resolution; that is, the numerical aperture of the objective used and the wave-length of the light. Numerical aperture is determined for us by the optician, and it is well known that, with an oil-immersion objective, a numerical aperture of 1·4 is at the present time the practical limit. Metallographers are in a somewhat stronger position, as a monobromide of naphthalene immersion objective was, and presumably still is, made by Zeiss which had a numerical aperture of 1·6. This represents the absolute limit at the present time, and there is no indication that numerical aperture will be increased in this sense by present methods.

The other factor governing resolution is the wave-length of light, and in this connection it must be borne in mind that to resolve a regularly marked structure the distance between the markings must be more than half a wave-length. Under ordinary conditions of illumination we cannot go very far in the direction of increased resolution unless we resort to an illuminant such as a mercury vapour lamp which is rich in blue and violet radiations. There is much room for investigation in this direction, as the ideal illuminant for microscopic work has yet to be found. But I do not know of any one that approaches so nearly to it as the one I have mentioned, the mercury vapour lamp. It suffers only from one disadvantage that I can see, and that is that the differentiation due to staining is not so clearly brought out as when ordinary light is used. But as staining is itself an artificial process, and is simply done to differentiate structures, it only means a certain amount of education to enable us to appreciate the differences even under the light from this lamp. The only stains which it does not show quite well, or rather in which the colour-tint is altered, are those in which red predominates. Any other colour is shown perfectly and in proper gradation. The advantages of this illuminant are that it is even and uniform. It has a fairly large area, and can be used, therefore, for any class of work. Its intensity can be varied within considerable limits by having a resistance in series, so that the current density is altered to suit the particular work under observation. Further, it is possible, by interposing neutral screens, to vary the light intensity if the electrical method is inconvenient. Owing to its possessing practically no red radiations its mean wave-length is shorter, and by using suitable screens light which is truly monochromatic, yellow, green, blue, or violet, can be obtained at will. These lamps are made both in glass and quartz, but the quartz ones are preferable, because they admit of the use of heavier currents with greater luminosity; and, further, they have a much longer life. I have exhibited two of these lamps, because I regard them as far in advance of any other form of light available to the microscopist at the present time, whether he is a biologist or a metallographer.

The whole subject of illumination needs investigation also, because there is, I think, little doubt that a modification in the intensity of the illumination of any particular object enables us to use a larger light-cone than we could do in ordinary circumstances —that is, variation of the intensity is an alternative to the use of the iris diaphragm in the sub-stage of the microscope. But it is in the direction of using invisible radiations in the ultra-violet, or, it may be, radiations which are still shorter than the ultra-violet, that developments in microscopic work are, in my opinion, likely to occur.

There are two other points worth mention, which I trust may be dealt with more fully in succeeding papers. One is that, while the resolution limits are so inflexible, that does not by any means apply to mere visibility. By illuminating small particles by means of an annular cone of rays—that is, what is ordinarily known as dark-ground illumination—or by illuminating them at right angles to the optic axis of the microscope—what is known as the ultra-microscopic method—particles of a very much smaller order of size can be made visible. But we cannot tell anything about their form, nor can we accurately tell their size. We are only conscious of their mere existence.

Another point to remember is that magnification is definitely limited to something like 750 diameters

with microscopes under ordinary conditions if we want to get the best optical effect. We may, as a matter of convenience, have still higher magnifications, because it is not given to everybody to appreciate fine detail unless an image is somewhat enlarged. But it must be appreciated that any increase beyond 750 or 800 diameters does not result in our seeing anything more. It simply allows us to see the object on a somewhat larger scale. We may, therefore, summarise as follows: An object which is much smaller in size than the resolution limit can be rendered visible provided the light with which it is illuminated is of sufficient intensity and sufficiently different in refractive index from the medium in which it lies. To resolve a series of equidistant points or lines in an object, their distance apart must exceed half a wave-length of light in the medium in which the object is immersed. Johnstone Stoney has shown that a pair of lines or objects can be separated when their distance apart is rather smaller than the resolution limit required for a number of points or lines in a row. But it should be borne in mind even here that the resolution limits apply if a clear standard of definition is required. An isolated object or pair of objects are not so well defined if they exceed the resolution limits as laid down for recurring structures. It cannot be too fully appreciated that illumination is the keynote of all sound microscopic work, and this applies whether the illumination is by means of visible radiation under ordinary conditions of work, or whether it is in experimental work in which the use of invisible radiations are concerned.

There is much room for research in this direction, and it is to be hoped that this is one of the points which will be seriously taken up. Apart from any question of research, the education of the user is perhaps of vital importance. It is of little use for opticians to make great efforts to turn out a satisfactory instrument if the user is incapable of taking advantage of the quality of the optical or other parts. I trust, therefore, that this symposium will give an impetus in this direction, and that it will help microscope-users to realise how much remains to be done.

MICROSCOPICAL OPTICS.[1]

IN the opening paragraphs attention is directed to the methods of treating the aberrations on the principle of equal optical paths (A. E. C., Monthly Notices of R.A.S., January and March, 1904, and April, 1905) and to the author's recent determination of the actual light distribution at and near the focus in the presence of aberration (Monthly Notices, June, 1919). The sine-condition is also discussed.

The origin and effects of the secondary spectrum are then dealt with, and the paper proceeds:

The attempts to produce varieties of *glass* free from this secondary spectrum have been unsuccessful so far as the microscope is concerned, for the existing crowns and flints with proportional dispersion have so little difference in dispersive power that an impracticable number of lenses would have to be used to secure the desired effect. We therefore still depend on the material the value of which for this purpose was discovered by Abbe, the natural mineral fluorite, used instead of crown glass in combination with heavy crown glasses or very *light* flint glasses in place of ordinary *dense* flint glass. It was by the use of fluorite that Abbe produced the apochromatic objectives, and fluorite of good optical quality must be used to this day to secure the result. Apart from the difficulty of finding this material, there is no obstacle to the designing by exact calculation of apochromatic objectives.

I now come to a defect of nearly all microscope objectives, and especially of highly corrected ones, which is well known to all practical microscopists, namely, the pronounced curvature of the field, invariably in the sense of requiring a shortening of the distance from object to lens in order to obtain a sharp focus in the outer parts of the field of view. The general theory of the primary aberrations of oblique pencils shows that any lens system when freed from astigmatism will have the curvature of field defined by the Petzval theorem, and that in the presence of astigmatism the two focal lines which then represent the strongest concentration of the light always lie both on the same side of the Petzval curve and at distances from it which are in the approximate ratio of three to one. When the astigmatism is undercorrected the natural curvature of the field defined by the Petzval equation becomes aggravated, whilst overcorrected astigmatism tends to flatten the field, and is deliberately introduced for this purpose in ordinary photographic objectives. The presence of considerable amounts of astigmatism, of course, renders really sharp marginal images impossible in either case, so that its absence, or, better still, a modest amount of overcorrected astigmatism, must be regarded as the ideal in microscope objectives. Unfortunately, this desirable state cannot be reached in the existing types of objectives. The binary low-power objectives up to the ordinary 1 in. and $\frac{2}{3}$ in. come nearest to it, and are, therefore, justly liked by microscopists for all work for which they are sufficiently powerful. In the ordinary ternary objectives of the $\frac{1}{2}$-in. type, with approximately plano-convex components, the curvature of the field is also of reasonably moderate amount. But it is a general experience that highly corrected objectives are very much worse as regards curvature of field. In the light of my most recent work on the general theory of lenses (Monthly Notices, November, 1919), this curious and objectionable peculiarity is easily explained, and becomes revealed as a *necessary* consequence of high spherical and chromatic correction if the usual number of components is adhered to. In the Lister and Amici types of ordinary objectives, which are fairly satisfactory as regards curvature of the field, the front lens is of such a form as to produce strong outward coma, and there is in the back lens or lenses a corresponding amount of inward coma.

The simple extensions of Seidel's theory, given in the paper last referred to, show that this is the state of affairs which tends to diminish undercorrected astigmatism, or even to reverse it into the more desirable overcorrected form. High correction of the zonal spherical aberration, and to a still greater extent complete removal of the spherical variation of chromatic correction, necessitate a more or less complete reversal of the coma effects in front and back components. In other words, with the usual types of objectives reductions of curvature and apochromatic or semi-apochromatic correction are completely antagonistic and incompatible; what benefits one correction is detrimental to the other. Fortunately, the extended theory also indicates a way out of this dilemma. It appears fairly certain that by building the objective itself on the lines required by the apochromatic condition, but leaving it spherically undercorrected, perhaps also chromatically overcorrected to a moderate extent, and with a considerable amount of outward coma (this is the most important), and by correcting these residuals in a *widely separated* additional back lens, it will be possible to combine moderate curvature of field with apochromatic perfection, and thus to remove the worst outstanding defect of the best objectives.

[1] From a paper by Prof. A. E. Conrady presented at a discussion on "The Microscope: Its Design, Construction, and Applications," organised by the Faraday Society at the Royal Society on January 14.

Condensers for the proper well-regulated *illumination* of microscopic objects are identical in optical design with objectives, the only difference being that the light passes through in the reverse direction, and that a lower degree of correction is sufficient not only on theoretical, but also on practical grounds, for nearly always condensers are used in conjunction with the "plane" mirror, which invariably is very far from optical perfection, and so introduces irregular aberrations of unknown magnitude and kind, and, moreover, the light from the condenser has to pass through the slide on which the object is placed. This slide is practically little better than window-glass so far as optical quality and perfection of surfaces are concerned, and the great variation in thickness is another source of imperfection, especially with dry condensers of high N.A.

Moderate amounts of residual aberrations in condensers can always be effectively neutralised by using a sufficiently large source of light of uniform brightness or by magnifying the source by a sufficiently well-corrected "bull's-eye," if the source of light is naturally small.

A great and very serious defect in the construction of nearly all condensers of the present day, with the exception of the modest Abbe condenser of two simple uncorrected lenses, is that the iris and the ring for dark-ground stops are placed too far from the back lens instead of being close to the anterior focal plane of the condenser. It is easily shown that such a remote iris-opening or dark-ground stop produces decidedly oblique illumination of the extra-axial points of the object. With direct light this leads to an undesirable variation in the type of image and in resolving power in different parts of the field. With dark-ground illumination the result is even more serious, for it is then necessary to use a far larger central stop to secure a dark background over the whole field than would suffice if the stop were placed close to the anterior focal plane of the condenser; such an unnecessarily large stop is highly objectionable, because it reduces the visibility of the coarser structures in the object.

The increasingly bad position of the iris in the condensers of higher power and shorter focal length supplies practically the whole explanation of the universal experience that high-power condensers will not work satisfactorily with low-power objectives, especially for dark-ground illumination.

The great thickness of the mechanical stage in English stands of the highest quality is the chief *reason* why the iris and "turn-out ring" of high-power condensers have to be mounted so far below the back lens, and a profound modification of the design of the stage with the view of making the part projecting over the condenser as thin as possible therefore appears to be the most desirable improvement of microscope stands from the optical designer's point of view.

As regards the *actual making of microscope objectives*, it must be borne in mind that the excellence of a computed lens system may be completely swamped by comparatively slight imperfections of workmanship, and that high accuracy in this respect is therefore of the utmost importance. In lenses of high N.A. computation shows that a departure from the prescribed radii and thicknesses by a fraction of a thousandth of an inch may lead to a notable loss of perfection, and the polished surfaces must also be truly spherical within less than half a wave-length of light. These limits can be easily observed if modern methods of gauging and measuring are adopted, and if all surfaces are polished to accurately made and conscientiously used test-plates. The tools and methods employed in really *manufacturing* lenses on this system were shown by Messrs. W. Watson and Sons, Ltd., at the exhibition at King's College in January, 1917, and will be found described and illustrated in the record of that exhibition.

In old English practice the component lenses of microscope objectives and condensers used to be fixed in their cells by cement of the sealing-wax type. Many old lenses which are still found in perfect adjustment fifty or more years after being mounted demonstrate that the cement may hold the lenses in correct position almost indefinitely; but other experiences, especially with lenses used in tropical countries, suggest that shifting may occur, and it is therefore strongly to be urged that all microscope lenses should be held between metallic shoulders at both ends by being bevelled into their cells, care being naturally required to avoid pressure and distortion through too tight a fit.

A point on which users of objectives err to their own detriment is an excess of faith in numerical aperture. I have heard microscopists boast of possessing an objective, say, of 1·43 N.A., whereas somebody else had one of barely 1·40; and a careful test would show that whilst the 1·43 was an indifferent lens, the 1·40 was excellent. The fancied advantage of 2 per cent., then, is really a disadvantage of perhaps 25 per cent. or more.

One of the few disservices which Abbe did to microscopy was the pushing of the N.A. of dry lenses to 0·95, and to a less extent the increase of that of oil lenses to 1·40. The extreme marginal zone of the apochromatic dry objectives of 0·95 N.A. is particularly badly corrected, so much so that the lenses will only bear a solid illuminating cone of about 0·65 N.A. even on the Abbe test-plate, and that with annular light bringing only the marginal zone into action correction-collar and tube-length combined do not allow of reaching a point of good spherical correction. There is no doubt that Abbe's own earlier dictum still holds, to the effect that beyond about 0·85 N.A. the higher aberrations become unmanageable unless the free working distance is reduced to a very few thousandths of an inch. A carefully computed objective of 0·85 N.A. will bear a full illuminating cone on suitable objects, and can thus realise its fullest resolving power. An objective of 0·95 with a condenser of 0·65 has the resolving power of the mean, or of 0·80 N.A., and is thus actually inferior, except for freak resolutions, with extremely oblique light. Oil objectives of more than 1·30, or at most 1·35, N.A. are also of very doubtful added value.

In closing this section I will once more quote without comment an anecdote of Fraunhofer, who received a complaint that a telescope supplied by him, although giving magnificent images, displayed certain fine scratches when examined with a magnifying-glass! The reply sent by Fraunhofer is reported to have been: "We have constructed the telescope to be looked through, not to be looked at."

A few sentences may perhaps be added as to the prospects for further improvements of microscopic performances. I have stated earlier in this paper that there is a bright ray of hope with regard to diminishing the curvature of field without loss of definition.

Advances in numerical aperture offer very little attraction. Abbe, in my opinion, carried the N.A. too far rather than not far enough, and I am not aware that any notable discovery has been achieved with the few monobromide immersion objectives of N.A. 1·60 which he designed.

The use of a shorter wave-length, *i.e.* ultra-violet light, is a little more promising. There would be none but technical difficulties to the construction of lenses suitable for this work. But as only very few

microscopists would be likely to go to the trouble of working in invisible light and of passing through a long apprenticeship in mastering the difficulties, apparatus of this description would necessarily be extremely costly, as the whole expense of designing and of constructing special tools would fall on a small number of outfits, or possibly on only a single one. And there would still be the grave drawback that the vast majority of objects would be opaque to extreme ultra-violet rays, and yield only black-and-white outline pictures.

The so-called ultra-microscope does not represent any advance in *resolving* power at all, but most decidedly the reverse. It is highly valuable for the detection of very minute particles and of their movements, which it achieves simply by intense dark-ground illumination, but the structure of the particles remains unrevealed, and only that would amount to an advance in resolving power. The seeing of these minute particles is, in fact, of precisely the same kind as the seeing of stars subtending less than 0·001 second of arc at night with the naked eye, the resolving power of which is of the order of 60 seconds.

PARIS ACADEMY OF SCIENCES.

BONAPARTE AND LOUTREUIL FOUNDATIONS.

OF the 72,500 francs placed at the disposal of the Academy by Prince Bonaparte, it is proposed to allocate 30,000 francs as follows:—

5000 francs to Charles Alluaud, travelling naturalist to the National Natural History Museum, for a geological and botanical expedition in the Moroccan Grand Atlas Chain.

2000 francs to A. Boutaric, for the construction of an apparatus for recording nocturnal radiation.

1000 francs to Emile Brumpt, for continuing his work on parasitic hæmoglobinuria or piroplasmos of cattle.

3000 francs to E. Fauré-Fremiet, for undertaking a series of studies on histogenesis and certain surgical applications.

3000 francs to A. Guilliermond, for pursuing his researches on lower organisms and on mitochondria.

3000 francs to Joseph Martinet, for continuing his researches on the isatins capable of serving as raw material for the synthesis of indigo colouring matters.

3000 francs to A. Vayssières, for the continuation of his researches of the marine molluscs, family Cyprædeæ.

10,000 francs to the Fédération française des Sociétés de Sciences naturelles, for the publication of a fauna of France.

The committee appointed to allocate the Loutreuil foundations recommend the following grants:—

(1) To establishments named by the founder:

10,000 francs to the National Museum of Natural History, for the reorganisation of its library.

7500 francs to the Paris Observatory, at the request of the Central Council of the Observatories, for purchasing an instrument.

(2) Grants applied for direct:

6000 francs to the Société Géologique du Nord, to enable it to take up work interrupted by the war.

10,000 francs to l'Ecole des hautes études industrielles et commerciales de Lille, for restoring the material of its chemical laboratory.

20,000 francs to the Observatory of Ksara (near Beyrout). This laboratory was practically destroyed by the Turks and Germans. The grant is towards its restoration.

8000 francs to Henri Deslandres, for the study of the radial movements of the solar vapours and the thickness of the gaseous atmosphere of the sun.

7500 francs to Maurice Hamy, to carry out certain improvements in astronomical apparatus of precision.

3500 francs to Félix Boquet, for the publication of Kepler tables.

1000 francs to G. Raymond, for the continuation of his actinometric experiments.

10,000 francs to Charles Marie, for exceptional expenses connected with the publication of the "Tables annuelles de constants et données numériques de chimie, de physique et de technologie."

10,000 francs to the Fédération française des Sociétés de Sciences naturelles, for the publication of a French fauna.

2000 francs to P. Lesne, for his researches on the insects of peat-bogs.

2000 francs to A. Paillot, for his researches on the microbial diseases of insects.

2000 francs to Just Aumiot, for the methodical study of the varieties of potato.

5000 francs to Albert Peyron and Gabriel Petit, for the experimental study of cancer in the larger mammals.

3000 francs to Th. Nogier, for completing the installation of the radio-physiological laboratory of the Bacteriological Institute of Lyons.

THE MATHEMATICAL ASSOCIATION.

THE annual meeting of the Mathematical Association was held in the London Day Training College, Southampton Row, on January 7 and 8, under the presidency of Prof. E. T. Whittaker. At the advanced section on the evening of January 7 the president gave a lecture on "A Survey of the Numerical Methods of Solving Equations." He described in some detail "iterative processes" for approximating to the roots and graphical methods of circumscribing the regions on the Argand plane, in which the various roots lay. The Lobachefsky-Graeffe method of approximating to the roots of equations and power series was described in considerable detail. In the animated discussion to which this lecture gave rise it was clearly seen that a wider knowledge of practical computative processes is a desideratum in all branches of mathematical work, which has been practically neglected hitherto in the schools and universities. It was also felt that such practical numerical work was the best possible introduction to the formal study of function theory, many of the ideas underlying which are usually presented in an entirely abstract way, whereas they present themselves naturally and of necessity in less general forms in the science of computation.

Next day, at the general section, Mr. C. Godfrey, of the Royal Naval College, Osborne, surveyed the whole question of the modern teaching of geometry in schools. He strongly favoured a preliminary course of practical instrumental work, to be followed by a more formal course in which "logic" is not too prominent. He advocated the entire postponement of a really rigorous course of abstract geometry until the post-school stage. Prof. T. P. Nunn strongly supported the general tenor of Mr. Godfrey's views, and urged the earlier teaching of "ratio and proportion" as a practical instrument for solving many problems, such as map-drawing, villa construction, etc.

Prof. E. H. Neville, of University College, Reading, next read a paper on "Convention and Duplexity in Elementary Mathematics," in which he protested against the usual "positive-sign" convention with regard to vectors. Miss H. M. Cook dealt with "The Place of Common Logarithms in Mathematical Training," and Prof. W. P. Milne strongly urged

the necessity of making both logarithms and numerical trigonometry compulsory for the university matriculation, because the work of the intermediate classes in the universities was being seriously hampered by the lack of such knowledge on the part of a large number of the students. Prof. Whittaker gave a most interesting paper on "Some Mathematical Problems awaiting Solution," which suggested themselves chiefly in computative work, such as the question of the convergence of certain approximative processes in the case of a large number of simultaneous equations. Mr. R. C. Fawdry opened a discussion on the teaching of mechanics to beginners, and said that, after many years' experience, he still could not decide whether to teach statics or dynamics first. A vigorous protest was entered by Dr. S. Brodetsky, Prof. W. P. Milne, and Mr. A. W. Siddons against the practice that had just arisen of teaching "pure mathematics" in the new advanced courses in secondary schools, thereby promoting undue specialisation at a young age and losing entirely the outlook which a combined course of pure and applied mathematics can supply.

The meetings were extremely well attended and very enthusiastic. WILLIAM P. MILNE.

INDUSTRIAL RESEARCH ASSOCIATIONS.

THE Department of Scientific and Industrial Research has just issued the following list of research associations which have been approved by the Department as complying with the conditions laid down in the Government scheme for the encouragement of industrial research, and have received licences from the Board of Trade under section 20 of the Companies (Consolidation) Act of 1908:—

British Boot, Shoe, and Allied Trades Research Association, Technical School, Abington Square, Northampton. *Secretary:* Mr. John Blakeman.

British Cotton Industry Research Association, 108 Deansgate, Manchester. *Secretary:* Miss B. Thomas.

British Empire Sugar Research Association, Evelyn House, 62 Oxford Street, London, W.1. *Secretary:* Mr. W. H. Giffard.

British Iron Manufacturers Research Association, Atlantic Chambers, Brazennose Street, Manchester. *Secretary:* Mr. H. S. Knowles.

British Motor and Allied Manufacturers Research Association, 39 St. James's Street, London, S.W.1. *Secretary:* Mr. Horace Wyatt.

British Photographic Research Association, Sicilian House, Southampton Row, London, W.C.1. *Secretary:* Mr. Arthur C. Brookes.

British Portland Cement Research Association, 6 Lloyd's Avenue, London, E.C.3. *Secretary:* Mr. S. G. S. Panisset.

British Research Association for the Woollen and Worsted Industries, Bond Place Chambers, Leeds. *Secretary:* Mr. Arnold Frobisher.

British Scientific Instrument Research Association, 26 Russell Square, W.C.1. *Secretary:* Mr. J. W. Williamson.

British Rubber and Tyre Manufacturers Research Association, c/o Messrs. W. B. Peat and Co., 11 Ironmonger Lane, E.C.2.

The Linen Industry Research Association, 2 Bedford Street, Belfast. *Secretary:* Miss M. K. E. Allen.

Glass Research Association, 7 Seamore Place, W.1. *Secretary:* Mr. E. Quine.

British Cocoa, Chocolate, Sugar Confectionery, and Jam Trades Research Association, 9 Queen Street Place, E.C.4. *Secretary:* Mr. R. M. Leonard.

Schemes for the establishment of research associations in the following industries have reached an advanced state of development:—

Research Associations Approved by the Department but not yet Licensed by the Board of Trade.—British Music Industries Research Association, British Refractory Materials Research Association, British Non-Ferrous Metals Research Association, and Scottish Shale Oil Research Association.

Proposed Research Associations the Memorandum and Articles of Association of which are under Consideration.—British Launderers Research Association, British Electrical and Allied Industries Research Association, and British Aircraft Research Association.

Industrial Organisations Engaged in Preparing Memorandum and Articles of Association.—Silk Manufacturers, Leather Trades, and Master Bakers and Confectioners.

In addition to the industries included above, certain others are engaged in the preliminary consideration of schemes for forming research associations.

THE ORGANISATION OF IMPERIAL STATISTICS.[1]

POINTING out that it was almost emphasising the obvious to say that any great nation should be thoroughly informed as to its numerical, its social, and its economic drift, the author directed attention to the fact that this had been recently recognised in a petition to his Majesty's Government so late as November 1 last. It was also emphasised by the calling together of a Conference of the Statisticians of the Empire, under the ægis of the British Government. In view of the position of the British Empire in world affairs, it was but little short of amazing that an Imperial Bureau of Census and Statistics was not long ago established. A bureau, to be really Imperial, must recognise the community of interest of all parts of the Empire. It was not something to be created mainly for the purposes of the United Kingdom, but something which would meet equally well the purposes of each part of the Empire. For this reason the needs of the autonomous Dominions must be quite as carefully considered as those of the United Kingdom itself, and it was implied in the paper that any part of the Empire which could not at present meet the common requirements of the whole must be prepared to do so. The interest would be general only in so far as it was Imperial.

In order to overcome departmental frictions and to secure the sympathy and co-operation of all public departments, it was suggested that a Central Statistical Commission should be created, the president of which would, of course, be the Director of the Bureau of Statistics. Such a Commission would be a body of expert advisers, and could make its departments helpful. The scope of an Imperial Statistical Bureau, both as to administrative procedure and as to subject-matter to be dealt with, was outlined, as was also the question of compilation and publication.

To attempt to organise an Imperial Bureau of Statistics with a small and humbly qualified staff would foredoom it to failure, said the author. In its higher professional section it must necessarily have experts in statistical theory, in the technique of the collection and compilation of statistical data, in pure and applied mathematics, in the languages which are important in the statistical field, in statistical editor-

[1] Abstract of a Paper presented to the Royal Statistical Society on Tuesday, January 20, by G. H. Knibbs, Statistician of the Commonwealth of Australia.

ship, in draughtsmanship and graphical representation, and in the interpretation and explanation of statistical results. In this last field the Director himself would, of course, be the expert *par excellence*, and not a mere administrator. It was also pointed out that to put the whole of the work in the hands of a mere administrator would lead to failure. The staff would, of course, include persons who specially studied demography, trade, production, finance, labour and industrial affairs, shipping, railways, tramways, and transport and communication.

In concluding, the author said that if the United Kingdom, by appropriate effort, were to supplement the efforts of some of the autonomous Dominions, it would be possible to build up a statistical edifice for the whole British Empire which, in meeting the needs of a great people—with its reactions upon the human race—would constitute the bureau a sort of *temple expiatoire* for our remissness in the past. The keynote of the whole paper was that an important duty has been left unfulfilled, and that we must not go on neglecting it, for such a work is needed by publicists and statesmen, and for the general purposes of intelligent criticism and intelligent government.

ITALIAN PAPERS ON RELATIVITY.

DR. ATTILIO PALATINI, of the University of Padova, Italy, dedicates a special paper (*Ac. d. Lincei*, April, 1919), entitled "Traiettorie dinamiche dei sistemi olonomi con tre gradi di libertà," to the investigation of what may shortly be called irreversible systems, *i.e.* systems the Lagrangian function of which contains the velocity (apart from its square) also linearly. The paper is but a generalisation of Birckhoff's investigation on "Dynamical Systems with Two Degrees of Freedom" (Trans. Amer. Math. Soc., vol. xviii., No. 2, 1917) to three degrees of freedom. The result arrived at is that the trajectories of such a system coincide with those of an ordinary system of three particles with appropriate constraints moving in a conservative field of force which spins uniformly about an axis. The analogy with such systems leads Dr. Palatini to take up in a second note, entitled "Moti Einsteiniani stazionari" (Ist. Veneto, May 11, 1919), the relativistic problem of what the author proposes to call *stationary* motions, *i.e.* such for which the four-dimensional line-element ds^2 contains non-vanishing, though constant, coefficients g_{14}, g_{24}, g_{34} (coefficients of the mixed, space-time terms, as $dx\,dt$, etc.). The chief result is again the equivalence to a three particles system in a uniformly revolving conservative system. It strikes one that this result could be read off the ds^2 almost directly. The result concerning the "anisotropic and irreversible" behaviour of energy is again obvious and, physically, of comparatively small interest.

The paper is inspired by Prof. Levi-Civita's recent investigations on *static* Einsteinian motions (*Ac. d. Lincei*, 1917, *et seq.*), for which g_{14}, etc., are permanently zero—elegant investigations, no doubt, but of purely formal interest.

Dr. Palatini's third recent article, "La Teoria di Relatività nel suo sviluppo storico" (*Scientia*, September–October, 1919), which, though not without many happy ideas as to the popular presentation of the "old" (1905) and the new or generalised relativity and gravitation theory, lacks that plasticity and freshness which would be imparted to it by a more intimate contact with existing physical ideas. This absence of contact goes in the present case (concluding section of part i., dedicated to the older theory of Einstein) even so far as to ignore the numerous and famous experimental proofs of the variability of mass with velocity. The author does not seem ever to have heard of the beautiful experiments of Kaufmann, Bucherer, Hupka, and others which have made the variability of β-particles an almost tangible fact. The second part of the article, devoted to general relativity, has the indisputable positive feature of being very enthusiastic, and gives, no doubt, some general idea of Einstein's newest doctrine. Yet even here one cannot help being surprised at one or two misconceptions, marring the introductory section on the concept of space-curvature, defects the more inexplicable as they emanate from a pure mathematician. Thus on pp. 16–17 we are invited to imagine some practically one-dimensional beings or animalcules living in three kinds of capillary tubes, a straight, a circular, and a hyperbolic one (devices not unfamiliar to any reader of the great Clifford). Having endowed these unfortunate beings with a sufficient amount of intelligence, Dr. Palatini (speaking of the first of them) proceeds to say: "In order to arrive from one to another point of its space, the being would state (*constatare*) that it had to follow the straight road." As if that poor thing had a choice in its one-dimensional abode! Equally misleading is not only the remainder of the history of these fictitious three beings, but also the presentation (p. 18) of our own concepts of the "spazio ambiente" in which we live.

Carlotta Longo gives, in her doctorate dissertation of 1918 (Padova), published in *Nuovo Cimento* (vol. xv., 1918, pp. 191–211), a very attractive and geometrically elegant investigation on the elementary electrostatic law according to Einstein's generalised relativity and gravitation theory. She confines herself to the special but most important case of a radially symmetric electrostatic distribution, and, integrating the field-equations in Prof. Levi-Civita's form adapted to the present case, finds for the electrostatic force a law which differs from Coulomb's inverse square law only in so far as the distance r from the centre of the field is replaced by the curvature radius of the geodetic sphere passing through the point in question. A further result of the investigation is that, in a radially symmetric field at least, there can be electric charge only where "there is also matter," unless it be a point-charge at the centre ($r=0$) itself. This striking result would deserve a more definite and critical enunciation. We are not told what kind of "matter" is meant, while, on the other hand, the energy of an electrostatic field is, for Einstein, also a kind of "matter." Yet another very interesting result is reached at the end of the paper. It relates to the "mechanical" force exerted by an electron, *if* its usual "electromagnetic mass" is assumed to be not only an inert, but also a gravitating (heavy) mass. The result is that, in addition to the quasi-Newtonian attraction, there is a *repulsion*, which, however, is comparatively small. Thus, for example, at a molecular distance from the centre the repulsion would be only one-hundred-thousandth of the gravitational attraction.

The paper is clearly written, and, being very suggestive, will certainly attract the attention of Einstein's followers. Nevertheless, one cannot help mentioning here that an excellent paper on this subject (which pushes the analytical, if not the geometrical, solution much farther) was published in 1916 by H. Reissner (*Annalen d. Physik*, vol. l., pp. 106–20). This paper, however, seems to have entirely escaped the notice of the author, whom nobody will fail to congratulate upon her elegant results.

L. SILBERSTEIN.

AGRICULTURE AT THE BRITISH ASSOCIATION.

AS might have been expected, the papers read before the Agricultural Section at the Bournemouth meeting had special reference to the abnormal conditions brought about by the war. Most of the members had been engaged either directly or indirectly in food production work, and there was a very marked reduction, as compared with normal years, in the amount of research work reported to the meeting.

[The presidential address appeared in NATURE of December 25, 1919, and need not, therefore, be further considered now.]

Two important papers dealing with the work of "Food Production" were read by Sir Thomas Middleton, formerly of the Food Production Department of the Board of Agriculture and Fisheries, and by Mr. J. M. Caie, an Assistant Secretary of the Board of Agriculture for Scotland, dealing with the methods and results of the food production schemes in England and Scotland respectively.

Sir Thomas Middleton revised the estimates, which he had brought forward at the Manchester meeting, of the number of persons who could be supported on the meat produced on 100 acres of average land under various conditions.

As compared with twelve to fourteen persons who could be supported on the meat produced on 100 acres of average grass land he estimated that :—

	Persons for a year
100 acres average wheat, milled as it was before the war, would support ...	200
100 acres milled (80 per cent.) would support	230
100 acres average barley (60 per cent.) would support	180
100 acres average oats (54 per cent.) would support	160
100 acres average potatoes would support	400
100 acres average mangolds would support	40
100 acres average meadow hay would support	14

Before the war the ploughed land in the United Kingdom was feeding about 84 persons per 100 acres, while the grass land was feeding about 20. Altogether we grew food for about 17,500,000 out of 46,000,000 people, or, in other words, we supplied the week-end requirements of the entire population throughout the year. The Food Production Department was set up in December, 1916, and by April, 1917, plans had been developed for bringing 2,700,000 acres of extra arable land into cultivation in 1918 over the 1916 area; and the agricultural returns for 1918 showed that, as compared with 1916, 1,842,000 additional acres in England and Wales were growing other crops than grass—roughly, two-thirds of the total additional area aimed at. Sir Thomas Middleton paid a high tribute to the assistance given by the scientific staffs of the agricultural departments of the universities and research stations.

As regards Scotland, Mr. J. M. Caie referred to the essential differences in the agricultural conditions of the two countries as exemplified by the following figures relating to 1917 :—

Country	Percentage of total cultivated area under	
	Permanent grass Per cent.	Rotation grass Per cent.
Scotland	30	31
England	58	9

The increased cropping was therefore to be secured much less by ploughing up old grass land and more by a shortening of the rotations on arable farms than was the case in England.

The increased area aimed at in 1918 was 350,000 acres, and of this 241,000 acres were obtained, or approximately 75 per cent. of the extension aimed at. It is a notable fact that the increased cropping was obtained without any appreciable reduction in the number of horses, cattle, and sheep.

It is believed that a noteworthy feature of the schemes for increased food production for Scotland will be their relatively low cost to the State. No special Food Production Department of the Board was set up; the number of officials attached to the Committees was kept down to a minimum, usually one, or at most two, to each Committee, many of them being officers of the agricultural colleges.

Dr. E. J. Russell read a paper of much interest on "War-time and Post-war Problems of Food Production," in which the author referred to the necessity for devoting renewed attention to drainage and liming in particular, and for providing an adequate amount of organic matter in the soil. He referred to the enormous waste in the preservation of farmyard manure, and to the difficulties of conserving the manure from dairies. The ploughing in of green crops was advocated and an increase in the clover crop, as a means not only of providing more keep, but also of increasing the amount of organic matter in the soil. With reference to manures, Dr. Russell stated that the production of ammonium sulphate had risen to 269,000 tons in 1919. Similarly, the production of superphosphate had risen from 560,000 tons in 1916 to 750,000 tons in 1919, and the amount of basic slag from 321,000 tons in 1916 to 540,000 tons in 1919. The British farmers are probably now using more artificial fertilisers than any other farmers in the world. The change in the composition of basic slag due to the alteration in the methods of manufacture was also dealt with, and the necessity for a complete revision of experimental field work with basic slag was insisted upon.

The possibility of the increased recovery of nitrogen from sewage by means of the "activated" process was also considered.

Amongst the other papers communicated were :—"The Value of Lupins in the Cultivation of Light Land," A. W. Oldershaw; "The Past Neglect and Future Improvement of Livestock in British Husbandry," K. J. J. Mackenzie; "The Electrical Treatment of Seeds," Dr. A. E. Blackburn; "The Composition of Linseed Recovered from Flax Crops," T. W. Fagan; and "The Classification of Cattle Foods," J. Alan Murray.

In the last-named paper Mr. Murray pointed out that the object of the classification should be to bring together in natural groups those foods that are of similar character and quality, irrespective of the concentration and the nutrients in them, and he suggested that the amount of available energy per pound of dry matter should be made the basis of classification. If the foods were arranged in this order the distinction between fresh and dry foods would vanish. No sharp line of demarcation between coarse and fine could be drawn, but the foods could be arranged in groups according to quality, and then might be subdivided according to the amount of digestible protein.

The more important foods in the main natural groups are as follows :—

(1) Cereal and pulse straws.

(2) Inferior hays.

(3) Grasses and clovers in flower, good hays, undecorticated cotton-cake.

(4) Mangels, pasture grass, wheat-bran, brewers' grains.

(5) Swedes, molasses, cabbages, oats, pollards, rape-cake.

(6) Potatoes, barley, sharps, peas, beans, decorticated cotton-cake.

(7) Locust beans, rye, wheat, middlings, cotton-seed, maize-germ cake, palm-nut cake, linseed cake.

(8) Maize, maize meal, gluten meal, gluten feed.

Mr. J. Mackintosh dealt with the outlook in dairying, especially with regard to the return obtained (*a*) on the sale of milk, (*b*) on cheese-making. The effect of the control of prices was discussed, and the possible effect of the high prices now allowed for fresh milk on the use of condensed and dried milk imported from other countries where milk is more cheaply produced. Similarly, in connection with the control of cheese, it was pointed out that if the British cheese-maker cannot produce at a much lower price when control is removed, he will have to meet very severe competition, and the outlook cannot be regarded as satisfactory.

A joint meeting was held with Section K (Botany) to discuss forestry problems. Prof. A. Henry, in a paper on "The Afforestation of Water-catchment Areas," advocated the afforestation of all gathering grounds, not only as a hygienic measure, but also as a means of increasing the timber reserves of the nation.

The enormous extent of these gathering grounds, more than 928,000 acres in extent, has not hitherto been recognised. Of this area 183,416 acres are owned by local authorities, but only in a few cases, *e.g.* Leeds, Liverpool, Manchester, and Birmingham, has the work of afforesting these gathering grounds been taken up seriously. Prof. Henry urged that all catchment areas still privately owned should be compulsorily acquired either by the corporation or by the State, and that all ground suitable for planting should be utilised.

Mr. R. L. Robertson, of the Forestry Commission, gave an interesting account of the work of his Department, but had little to say as to its future policy—a question on which the audience would have been glad of some information. Other speakers included Sir Daniel Morris, Prof. Somerville, and Mr. Duchesne. Mr. W. E. Hiley read a paper on "Sources of Infection of Forest Trees by Fungi."

The work of the Section concluded with an excursion to Iwerne Minster, by kind invitation of Mr. Ismay, where the home farm and stock were inspected.

ALEX. LAUDER.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE annual oration in connection with the Medical Society of London will be delivered on Monday, May 10, at 9 o'clock, by Sir D'Arcy Power, who will speak on "The Rev. John Ward and Medicine."

THE Irish Geographical Association, which now enters upon its second year in close connection with the Geographical Association in Great Britain, has elected Prof. Grenville A. J. Cole as president for 1920, and Miss F. M. Berry, 15 Lower Leeson Street, Dublin, as hon. secretary.

THE following are among the forthcoming free courses of public lectures at Gresham College:—Physic, by Sir R. Armstrong-Jones (January 20 to 23); Geometry, by W. H. Wagstaff (February 3 to 6); and Astronomy, by A. R. Hinks (February 17 to 20). The lecture-hour will be 6 o'clock.

A MEETING of zoologists was held in the rooms of the Linnean Society on Friday, January 9, to consider, among other matters, the teaching of zoology in schools and the salaries and remuneration of zoologists in general. Prof. S. J. Hickson presided, and after discussion the following resolutions were passed unanimously:—(1) That this meeting of British zoologists considers that paragraph 10 of the Report of the Investigators of the Secondary School Examinations Council, appointed to inquire into the methods and standards of award in the seven approved First Examinations held in July, 1918, referring to the subjects of natural history and zoology, is likely to discourage the teaching of zoology in secondary schools, and requests the Zoology Organisation Committee to take such steps as may seem desirable to submit to the Board of Education the views of zoologists on the subject. (2) That this meeting deplores the present difficulty in filling vacancies in the scientific staff of the Natural History Museum, and regards it as mainly due to the poor pay and prospects of the members of the staff. It is of the opinion that this, if not remedied, will react adversely not only on the work of the museum, but also on the advance of zoology in this country. It therefore requests the Zoology Organisation Committee to make such representations in the matter as may seem desirable.

UNDER the title *Discovery*, Mr. John Murray has just published the first number of a monthly periodical intended to promote intelligent interest in all branches of intellectual activity and practical achievement. The journal had its origin in a conference held a short time ago at which representatives of many literary, educational, and scientific associations were present. It has the blessing of these associations, and support in the form of suggestions for contributors and subjects of articles. It is to be maintained under a deed of trust, and the trustees, whose names appear on the cover of the magazine, include the presidents of the Royal Society and the British Academy. There is also a committee of management, which will apparently advise the editor, Dr. A. S. Russell, as to the suitability or otherwise of articles submitted or solicited. With such distinguished patronage and competent opinion, *Discovery* should be able to provide interesting fare month by month for the delectation and profit of many thoughtful minds. Prof. R. S. Conway, who has been largely responsible for the inception of the journal, opens the first number with an instructive article on "The Secret of Philæ," particularly with regard to Gallus the prefect and his relations with the poet Virgil. The other articles are on smoke-screens at sea, Dr. T. Slater Price; the modern study of dreams, Prof. T. H. Pear; discovery and education, the Master of Balliol; the Conference at Paris, J. W. Headlam-Morley; sound-ranging in war-time, Dr. A. S. Russell; and Spitsbergen, Dr. Rudmose Brown.

SOCIETIES AND ACADEMIES.

MANCHESTER.

Literary and Philosophical Society (Chemical Section), December 18, 1919.—Mr. H. N. Morris in the chair.—H. **Moore**: Future supplies of motor fuel. The author dealt with the possibility of meeting the future demand by an increased production of petroleum spirit; benzol as a motor fuel; alcohol as a motor fuel; and the advantages of mixed motor fuels, with particular reference to the compression pressures of engines and to the vapour tension of mixed fuels.

Literary and Philosophical Society, January 6.—Prof. F. E. Weiss, deputy chairman, in the chair.—R. W. **James**: The Antarctic: Shackleton's Expedition of 1914–17. A description of the life and scientific work of the expedition and of the explorations round the

Weddell Sea, Ross Sea, Elephant Island, and South Georgia. The scientific results especially described included the mapping of two hundred miles of new coast-line, soundings in the Weddell Sea, and the study of the natural history of pack-ice.

DUBLIN.

Royal Dublin Society, December 16, 1919.—Prof. H. J. Seymour in the chair.—Prof. H. H. **Dixon** and T. G. **Mason**: A cryoscopic method for the estimation of sucrose. The depression of freezing point of a solution of sucrose is approximately doubled by inversion. It is evident then that the sucrose content may be estimated by determining the freezing point of a solution before and after inversion. This may be conveniently done by the thermo-electric method of cryoscopy. It is convenient to add the invertase to the fluid to be examined in the cold. Without allowing the temperature to rise above 0°, the freezing point is determined. The mixture is then incubated for forty-eight hours at 30°, and the freezing point again observed. The difference between the two observations is a measure of the amount of sucrose originally present. The method has the advantages that only small quantities of the fluid are required (2·5 c.c.), and treatment to remove proteins and other colloids is unnecessary. Using thermo-couples of easily attained sensibility, amounts of about 1 mgr. of sucrose may be detected.—Prof. S. **Young**: Brown's formula for distillation. Evidence, based on the theoretical work of Rosanoff, Bacon, and Schulze, is brought forward in support of the conclusion that Brown's formula is applicable to mixtures of chemically closely related liquids, and that the constant in the formula is equal to the ratio of the vapour pressures of the two pure substances at the boiling point of the mixture.—Miss Anne L. **Massy**: The Holothurioidea of the coasts of Ireland. Twenty-five species are enumerated, belonging to thirteen genera. No new species are described, but the following are added to the British-and-Irish area:—*Stichopus regalis*, Cuvier, *Mesothuria Verrilli*, Théel, and *Benthogone rosea*, Koehler, and the belief is expressed that the previous records of *Bathyplotes natans*, Sars, and *Holothuria aspera*, Bell, are referable to *Bathyplotes Tizardi*, Théel, and *Mesothuria lactea*, Théel. Ten of the species dealt with are restricted in the area to the Irish Atlantic slope.

MELBOURNE.

Royal Society of Victoria, November 6, 1919.—Mr. J. A. Kershaw, president, in the chair.—F. **Taylor**: Australian phlebotomic Diptera, new Culicidæ and Tabanidæ, and synonymy. Descriptions are given of a new mosquito, *Uranotaenia albofasciata*, and two new species of Tabanidæ, *Sylvius distinctus* and *Tabanus Geraldi*; whilst a new genus, Phibalomyia, is suggested for Elaphromyia, previously occupied.—A. J. **Ewart**: The synthesis of sugar from formaldehyde and its polymers, its quantitative relations, and its exothermic character. The author's experiments, conducted over a long period, point to the conclusion that sugar in plants is formed directly, and not by the intervention of formaldehyde.—H. B. **Williamson**: A revision of the genus Pultenæa. The members of this genus present some difficulties as to specific limitations, and the work, of which this is a first instalment, dealing with about thirty species, has been undertaken to place it on a more practical basis. It is expected that few species will be erected, and that there may be a reduction of one or two that have been recently described. The conclusions have been based on an exhaustive examination of specimens from all the Australian States.

SYDNEY.

Linnean Society of New South Wales, October 29, 1919.—Mr. J. J. Fletcher, president, in the chair.—Prof. C. **Chilton**: A new Isopodan genus (fam. Oniscidæ) from Lake Corangamite, Victoria. *Haloniscus Searli*, n.g. et sp., described from a number of specimens obtained from the waters of Lake Corangamite, is assigned to the family Oniscidæ, one of the most strictly terrestrial families of Isopoda. The author suggests that Haloniscus is the descendant of a form that was terrestrial in habits, and that, owing to special circumstances arising from its habitat, it has become re-adapted to aquatic life.—J. H. **Maiden**: Notes on the coloration of the young foliage of Eucalyptus. A series of observations is recorded of the colour of the young foliage in a number of species of Eucalyptus growing wild or cultivated in the Sydney district. The interesting suggestion is put forward that the observations justify the belief that a number of species and some groups can be diagnosed by this means.—E. F. **Hallmann**: New genera of Monaxonid sponges related to the genus Clathria. Ten genera are proposed as new.—A. M. **Lea**: Description of new species of Australian Coleoptera. Part xv. Thirty-one species, belonging to fourteen genera in the groups Scarabæidæ, Melandryidæ, and Cerambycidæ, are described as new.

Royal Society of New South Wales, November 5, 1919.—Dr. R. Greig-Smith, vice-president, in the chair.—R. H. **Cambage**: Acacia seedlings. Part v. The author describes ten species of Acacia seedlings. He records various species having flowered in 5-in. and 6-in. pots. One seedling of *A. montana*, three years old and 4 ft. high, bore about 3000 flowers. A seedling of *A. diffusa* and another of *A. cardiophylla* had flowered when only seventeen and nineteen months old respectively. Seeds of *A. melanoxylon* and *A. penninervis* had readily germinated after having been immersed in sea-water for 889 days.—Prof. C. E. **Fawsitt** and C. H. **Fischer**: The miscibility of liquids. The authors have examined a considerable number of liquids in regard to their mutual solubility or miscibility. The mutual solubility of two liquids depends greatly on the molecular volume of these liquids, and the molecular volume again depends on the chemical composition. The knowledge of the chemical composition of a liquid gives some indication of its behaviour in regard to solubility in other liquids.—J. G. **Stephens**: A new method of measuring molecular weights. The author employs the fact that isotonic solutions have equal vapour pressures as a means of determining molecular weights. Two tubes each containing a solution of different substances in the same solvent are placed in communication. Distillation occurs from one tube to the other until the solutions become isotonic, when the molecular weight of one of the substances may be calculated in terms of that of the other.

BOOKS RECEIVED.

The Romantic Roussillon: In the French Pyrenees. By I. Savory. Pp. xii+214+plates. (London: T. Fisher Unwin, Ltd.) 25*s.* net.

The Foundations of Music. By Dr. H. J. Watt. Pp. xvi+239. (London: At the Cambridge University Press.) 18*s.* net.

The Adventive Flora of Tweedside. By I. M. Hayward and Dr. G. C. Druce. Pp. xxxii+296. (Arbroath: T. Buncle and Co.)

The New Hazell Annual and Almanack for the Year 1920. Pp. liv+941. (London: H. Frowde and Hodder and Stoughton.) 6*s.* net.

DIARY OF SOCIETIES.

THURSDAY, JANUARY 22.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Dr. R. R. Terry: Renaissance Music in Italy and England.

ROYAL SOCIETY, at 3.30 (Special General Meeting). At 4.30.—Prof. E. G. Coker and K. C. Chakko: The Stress-strain Properties of Nitro-cellulose and the Law of its Optical Behaviour.—S. Marsh: Alternating-Current Electrolysis.—W. H. Eccles and J. H. Vincent: The Variations of Wave-length of the Oscillations Generated by the Three-Electrode Thermionic Tube due to Changes in Filament Current, Plate Voltage, Grid Voltage, or Coupling.—S. D. Carothers: Plane Strain. The Direct Determination of Stress.—F. Horton and Ann C. Davies: An Investigation of the Effects of Electron Collisions with Platinum and with Hydrogen, to ascertain whether the Production of Ionisation from Platinum is due to Occluded Hydrogen.—L. Bairstow, R. H. Fowler, and D. R. Hartree: The Pressure Distribution on the Head of a Shell moving at High Velocities.

INSTITUTION OF MINING AND METALLURGY (at the Geological Society), at 5.30.—W. Broadbridge: Froth Flotation: Its Commercial Application and its Influence on Modern Concentration and Smelting Practice.

INSTITUTION OF ELECTRICAL ENGINEERS (at the Institution of Civil Engineers), at 6.—J. L. Thompson: Transformers for Electric Furnaces.

CONCRETE INSTITUTE (296 Vauxhall Bridge Road), at 7.30.—Dr. J. S. Owens: The Attrition of Concrete Surfaces exposed to Sea Action.

HARVEIAN SOCIETY (at the Medical Society of London), at 8.15.—Annual General Meeting.

FRIDAY, JANUARY 23.

ROYAL SOCIETY OF MEDICINE (Study of Disease in Children Section), at 4.30.

PHYSICAL SOCIETY OF LONDON (at the City and Guilds Technical College, Leonard Street), at 5.—Dr. J. H. Vincent: Maintained Oscillations in Triode Valve Circuits.—Dr. W. Eccles: Measurements of the Chief Parameters of Triode Valves.—F. W. Jordan: Measurement of Amplification of a Radio-frequency Amplifier.—F. E. Smith: The Measurement of Amplification given by Triode Amplifiers at Audible and at Radio Frequencies.—Hon. C. W. Stopford and C. R. Darling: Exhibition of a Method of Determining the Hardening Temperature of Steel.—C. R. Darling: Exhibition of a Thermal Cell of Constant Voltage.

ROYAL COLLEGE OF SURGEONS, at 5.—Prof. A. Keith: John Hunter's Observations and Discoveries in Anatomy and Surgery: His Contributions to our Knowledge of the Alimentary System (Hunterian Lecture).

INSTITUTION OF MECHANICAL ENGINEERS, at 6.—E. M. Bergstrom: Recent Advances in Utilisation of Water Power.

JUNIOR INSTITUTION OF ENGINEERS (at 39 Victoria Street), at 7.30.—J. A. Reavell: Evaporation in the Chemical Industry.

ROYAL SOCIETY OF MEDICINE (Epidemiology and State Medicine Section), at 8.30.—Dr. F. G. Crookshank: Principles of Epidemiology.—Dr. Cleland and Dr. Campbell: Epidemiology of Acute Encephalomyelitis.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Hon. Sir Charles Parsons: Researches at High Pressures and Temperatures.

SATURDAY, JANUARY 24.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—A. Noyes: Aspects of Modern Poetry.

PHYSIOLOGICAL SOCIETY (at King's College), at 4.

MONDAY, JANUARY 26.

ROYAL COLLEGE OF SURGEONS, at 5.—Prof. A. Keith: John Hunter's Observations and Discoveries in Anatomy and Surgery: His Contributions to our Knowledge of the Kidneys, Bladder, and Urethra, and Diseases connected with these Structures (Hunterian Lecture).

ROYAL SOCIETY OF ARTS, at 8.—Capt. B. Hamshaw Thomas: Aircraft Photography in War and Peace (Cantor Lecture).

ROYAL SOCIETY OF MEDICINE (Odontology Section), at 8.—S. F. St. J. Steadman: Dental Sepsis in Children: Its Consequences and Treatment.

MEDICAL SOCIETY OF LONDON, at 8.30.—Pathological Evening.

TUESDAY, JANUARY 27.

ROYAL HORTICULTURAL SOCIETY (at Vincent Square, S.W. 1), at 3.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Prof. G. Elliot Smith: The Evolution of Man and the Early History of Civilisation: I. Man's Origin.

INSTITUTION OF CIVIL ENGINEERS, at 5.30.—J. Mitchell: Whitby Harbour Improvement.—R. F. Hindmarsh: The Design of Harbours and Breakwaters with a View to the Reduction of Wave-action Within Them.—J. W. Sandeman: Wave-action in Harbour Areas; with Special Reference to Works for Reducing it at Blyth and Whitby Harbours.—W. Simpson: The Improvement of the Entrance to Sunderland Harbour, with Reference to the Reduction of Wave-action.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Lantern Meeting), at 7.—Major W. Bladon: Life on the Gold Coast.

ROYAL ANTHROPOLOGICAL INSTITUTE, at 8.15.—Annual General Meeting

WEDNESDAY, JANUARY 28.

ROYAL SOCIETY OF ARTS, at 4.30.—Sir Cecil Hertslet: The Ruin and Restoration of Belgium.

ROYAL COLLEGE OF SURGEONS, at 5.—Prof. A. Keith: John Hunter's Observations and Discoveries in Anatomy and Surgery: His Contributions to our Knowledge of the Genital and Reproductive Systems (Hunterian Lecture).

BRITISH ACADEMY (at the Royal Society), at 5.—Dr. C. Singer: Magic and Medicine in Early England.

THURSDAY, JANUARY 29.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Dr. R. R. Terry: Renaissance Music in Italy and England.

ROYAL SOCIETY, at 4.30.—*Probable Papers*: Prof. W. Bateson: The Genetics of "Rogues" among Culinary Peas (*Pisum sativum*).—L. T. Hogben: Studies on Synapsis. I. Oogenesis in the Hymenoptera.—H. Onslow: A Periodic Structure in many Insect Scales, and the Cause of their Iridescent Colours.

ROYAL COLLEGE OF PHYSICIANS, at 5.

ROYAL SOCIETY OF MEDICINE (Balneology and Climatology Section), at 5.30.—Dr. N. Wood and Others: Discussion on the Merits and Defects of the British Health Resorts.

WIRELESS SOCIETY OF LONDON (at Institution of Civil Engineers), at 6.—R. C. Clinker: A Portable Valve Set and some properties of C.W. Circuits.

FRIDAY, JANUARY 30.

ROYAL COLLEGE OF SURGEONS, at 5.—Prof. A. Keith: John Hunter's Observations and Discoveries in Anatomy and Surgery; His Contributions to our Knowlege of the Eye, Ear, and Nose (Hunterian Lecture).

INSTITUTION OF ELECTRICAL ENGINEERS (Students' Meeting) (at the City and Guilds Technical College, Leonard Street), at 7.—Major K. Edgcumbe and Others: Discussion on Quantity Production as a Panacea.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—S. G. Brown: The Gyrostatic Compass.

SATURDAY, JANUARY 31.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Sir F. W. Dyson The Astronomical Evidence bearing on Einstein's Theory of Gravitation I. Movement of the Perihelion of Mercury.

PHYSIOLOGICAL SOCIETY (at King's College), at 4.

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